Comparison of ENSO signal in AMSR-E fields and GISS GCM simulation

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AMSR-E Science Team Meeting

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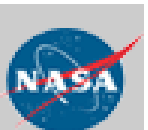

COLUMBIA UNIVERSITY
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Motivation

— To investigate ENSO response in GISS GCM

- Objectively extract ENSO response in a given field
- AMSR-E measurements of atmospheric responses

➔ To evaluate GCM's ENSO response and to study the possible reasons for not simulating ENSO well

Methodology

Extract El Niño signal in a given field X (J. Chen, 2005)

$$Xs_{i,m} = N34_{m+j} \times ECLL_i \times \sigma_{X_i} / \sigma_{N34}$$

X – the anomaly field of the quantity of interest
Xs – ENSO signal in X
N34 – NINO3.4 index
ECLL – Extreme Correlation at Least Lag
σ_{Xi} – Standard deviation of X
σ_{N34} – Standard deviation of Niño3.4 index
***i* –** grid box *i*
***m* –** time step *m*
***j* –** lag *j*

Methodology

Extract El Niño signal in a given field X (J. Chen, 2005)

$$Xs_{i,m} = N34_{m+j} \times ECLL_i \times \sigma_{X_i} / \sigma_{N34}$$

Advantages:

- **Objectively get ENSO signal**
- **Capture both in-phase and the lagged remote response**

Data and Model

Data:

AMSR-E Level 3 Rainfall and Ocean products (Version 1)

- **2002.06 – 2005.01**
- **5°x5° AE_RnGd precipitation**
- **0.25°x0.25° AE_MoOcn: SST, CLW, CWVP**

TRMM-3A12 (V6) for AMSR-E period

- **stratiform-convective partitioning**
- **latent heating profiles**

Model: GISS SI2000 AGCM with updates:

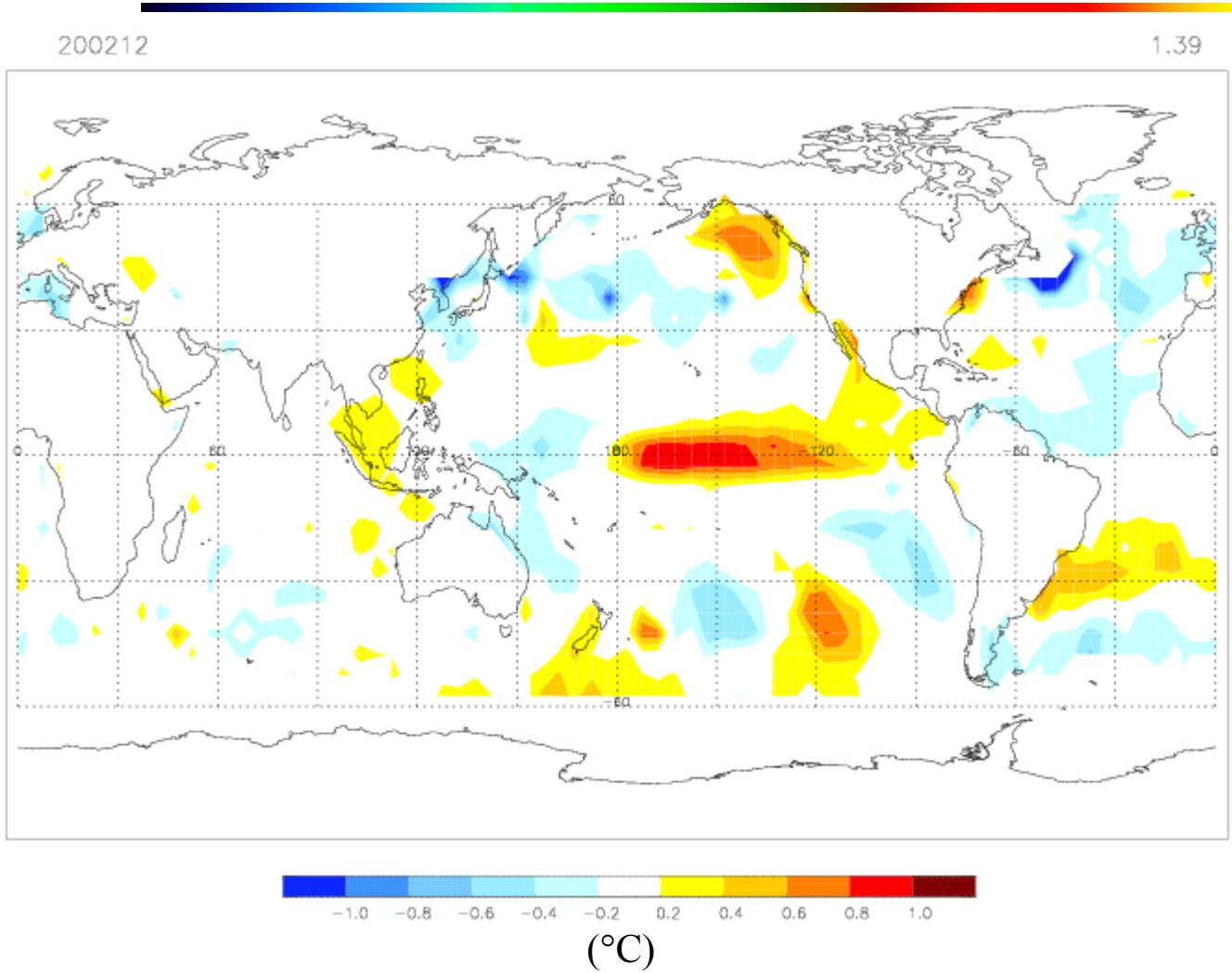
Resolution – 2° x 2.5° x 32 L

Boundary layer scheme – Schmidt et al. (2005)

Cumulus/stratiform clouds – Del Genio et al (2005)

Forced by observed SST from Hadley Centre

2002-03 El Niño Evolution in AMSR-E SST field

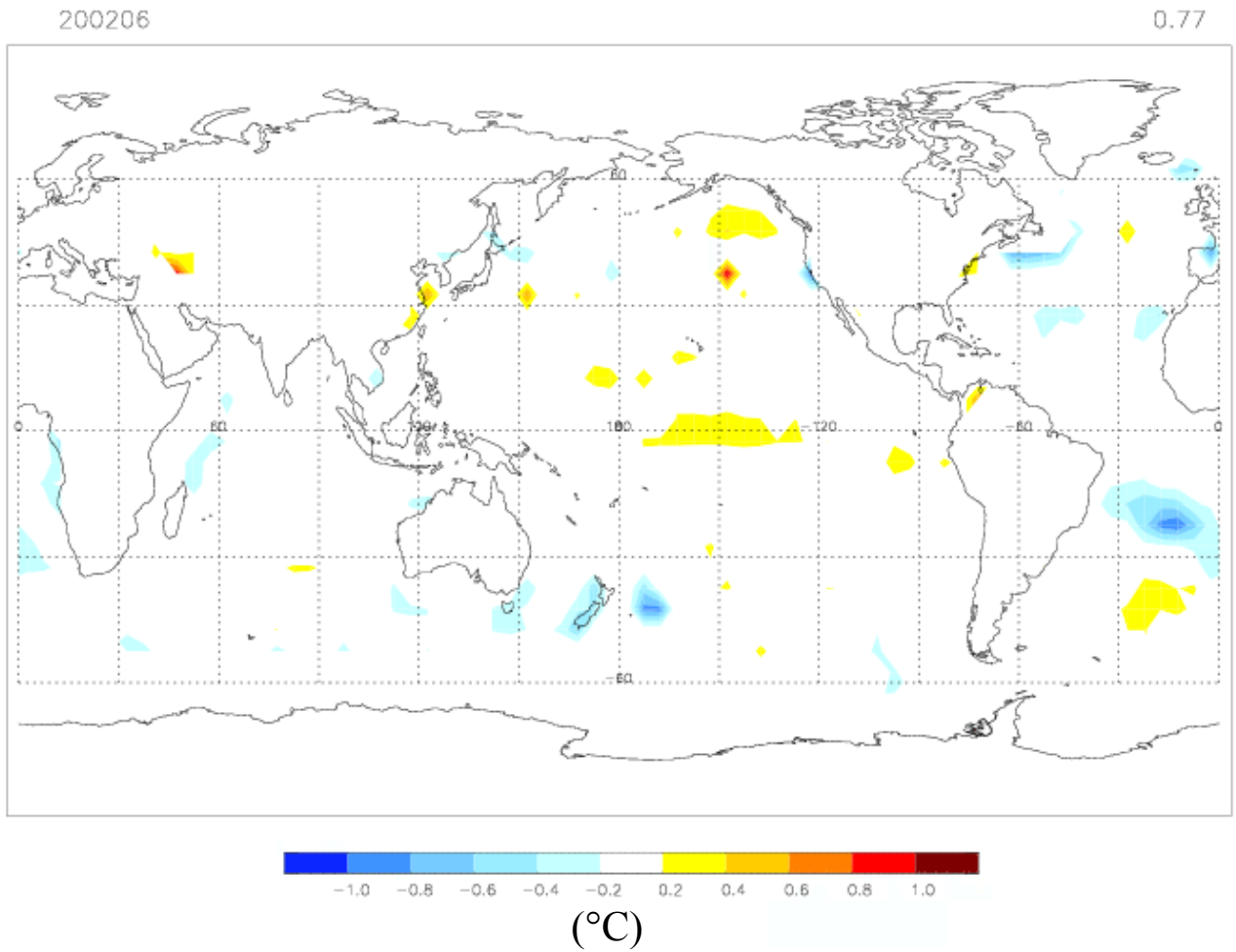


AMSR-E SST anomaly map for 2002-03 El Niño

<u>El Nino pattern:</u>

- positive SST anomaly in central and eastern Pacific
- negative SST anomaly in western Pacific
- telenconnection between tropical Pacific and extratropic Pacific

2002-03 El Niño Evolution in AMSR-E SST field

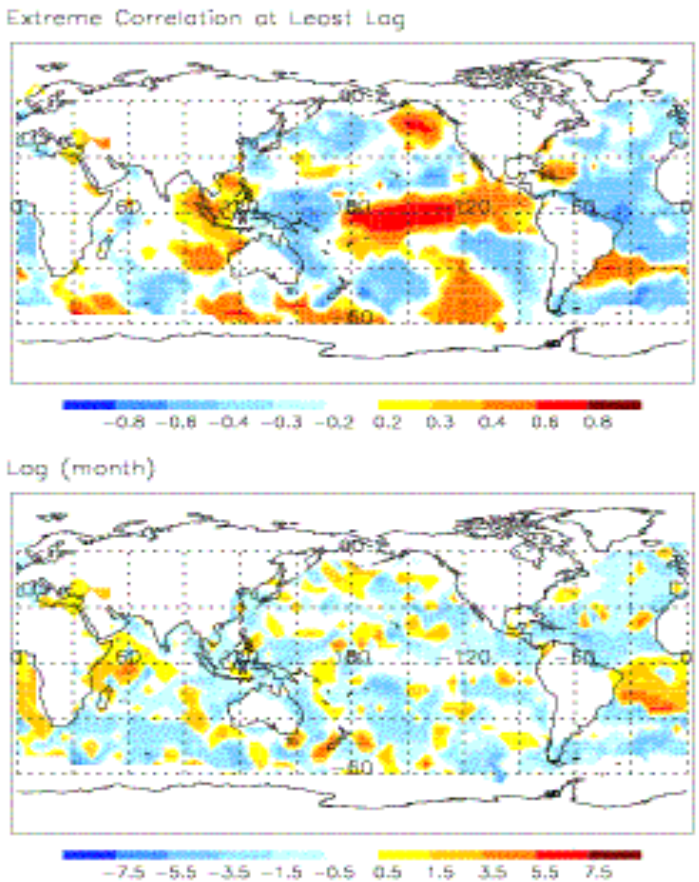


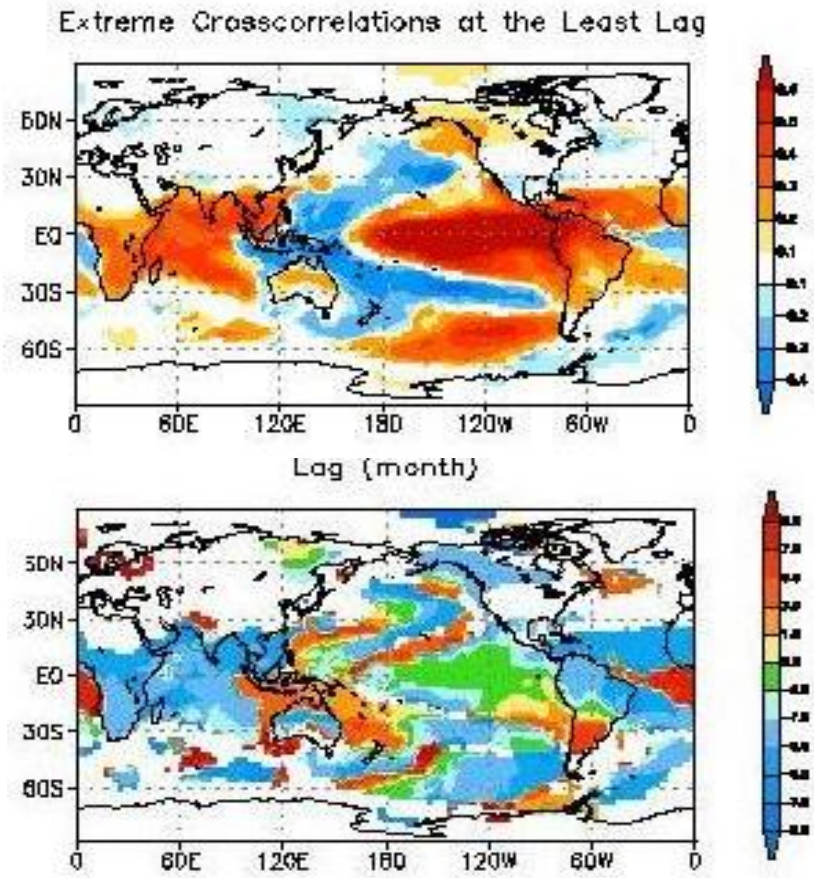
Evolution of SST anomaly during AMSR-E period Jun. 2002 – Jan. 2005

Correlation and Lag in AMSR-E and GISTEMP SAT fields

ECLL ➔

Lag ➔ (month)



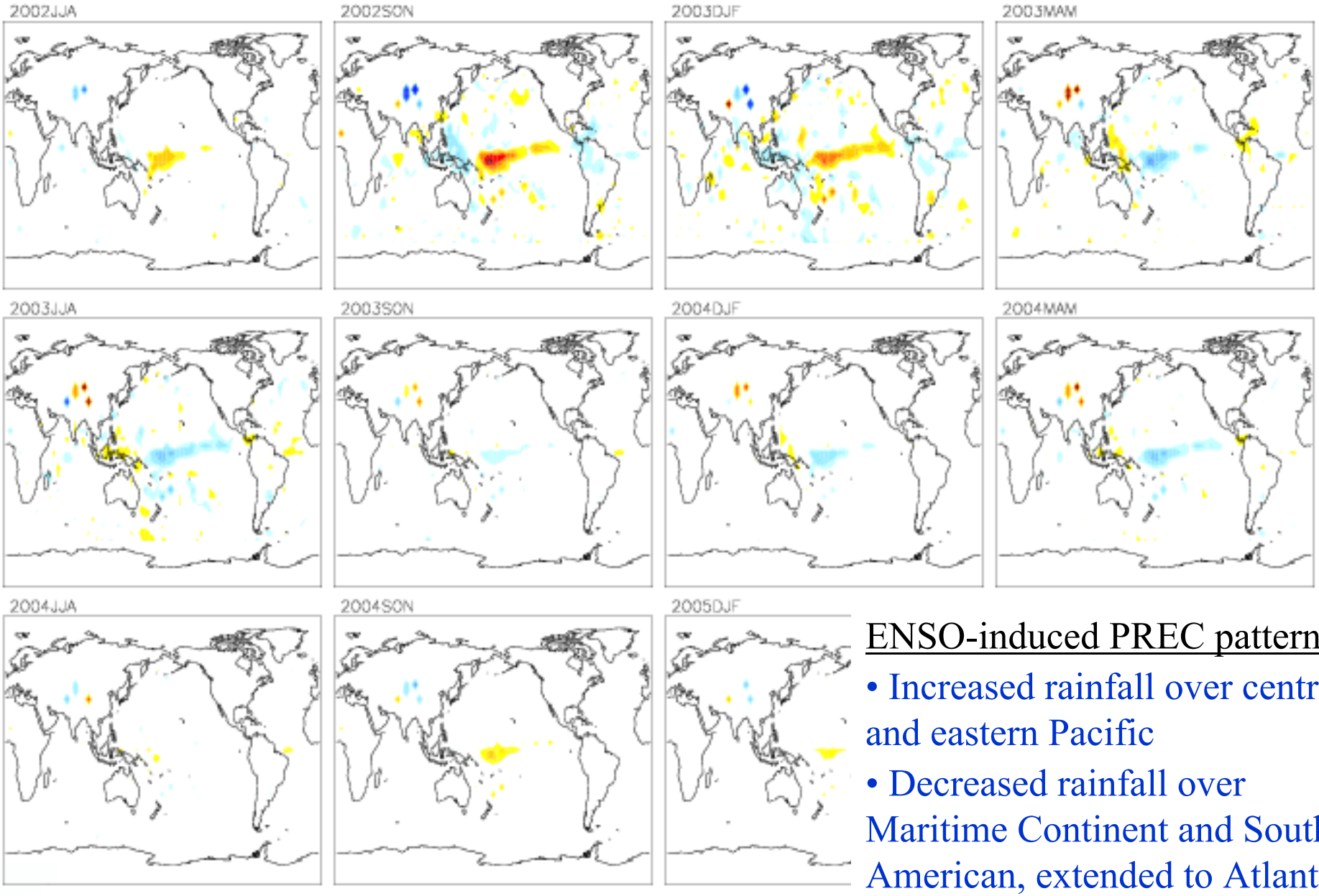


AMSR-E

GISTEMP SAT(J. Chen, 2005)

- Over AMSR-E period, a weaker linkage between Indian Ocean and ENSO; and opposite correlation over Atlantic Ocean
- Lag signal clearly shown when integrated with time

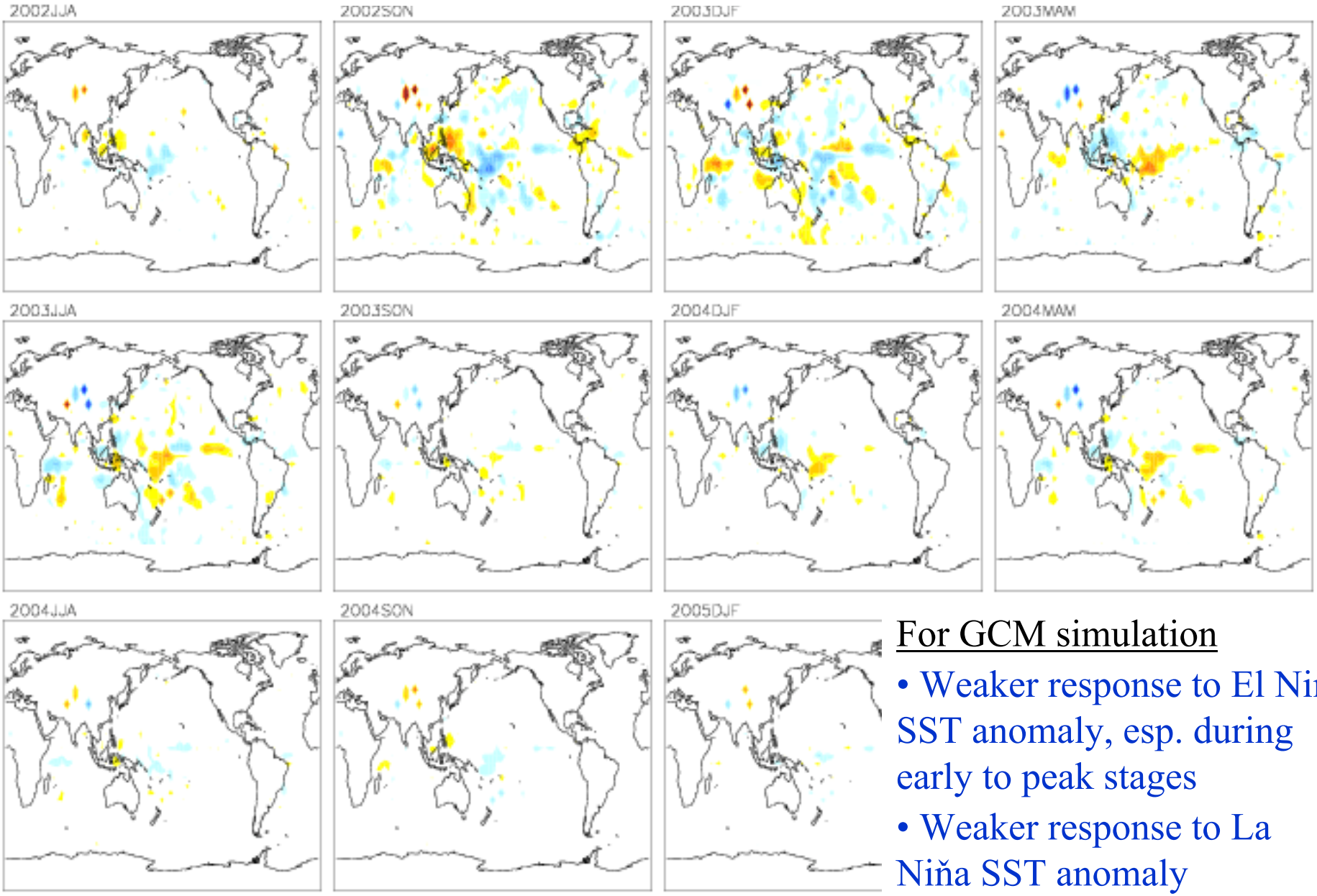
2002-03 El Niño Evolution in AMSR-E Precipitation at Seasonal Scale



ENSO-induced PREC pattern

- Increased rainfall over central and eastern Pacific
- Decreased rainfall over Maritime Continent and South American, extended to Atlantic

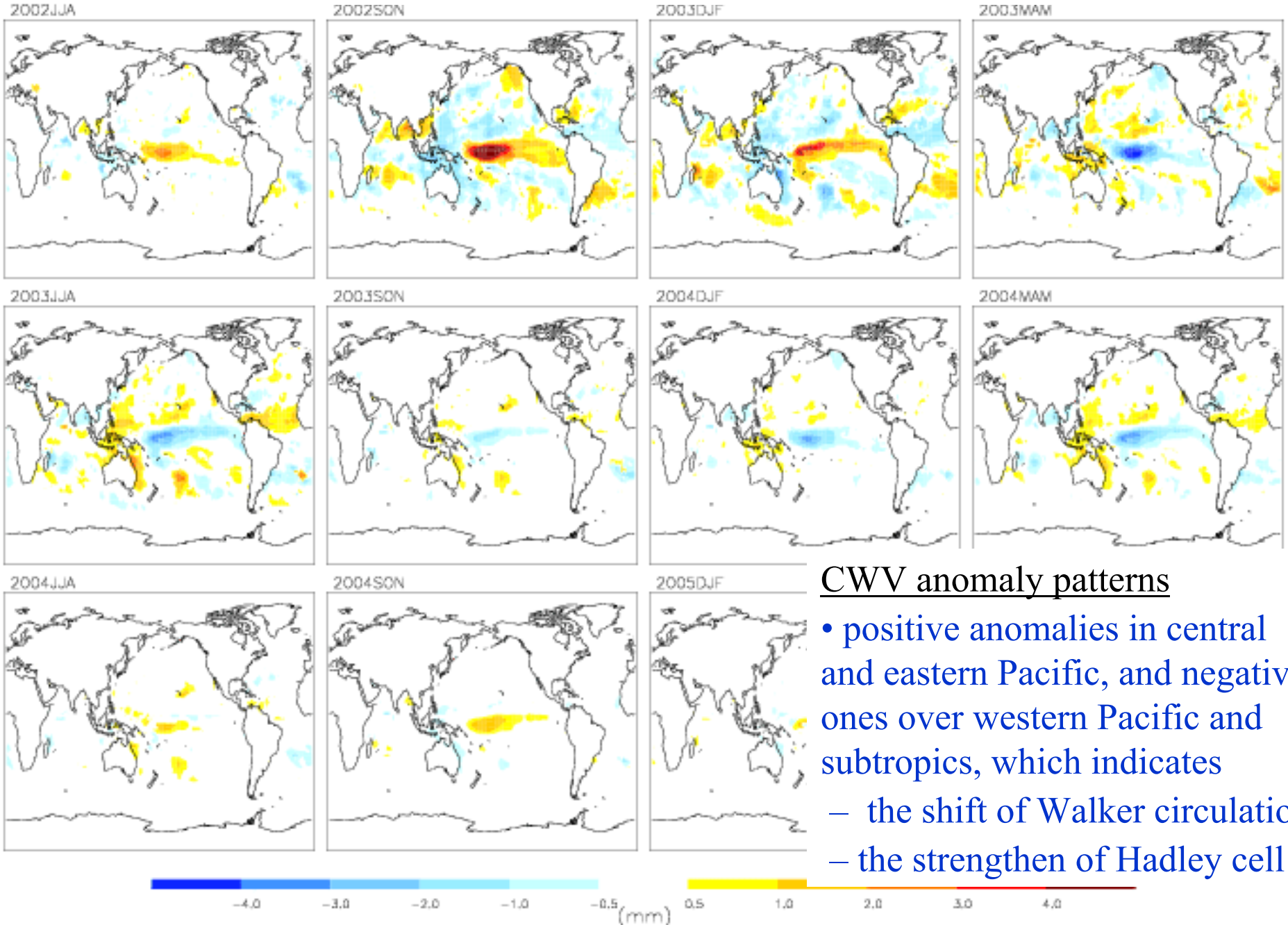
2002-03 El Niño Anomaly Difference: GCM – AMSR-E PREC



For GCM simulation

- Weaker response to El Niño SST anomaly, esp. during early to peak stages
- Weaker response to La Niña SST anomaly

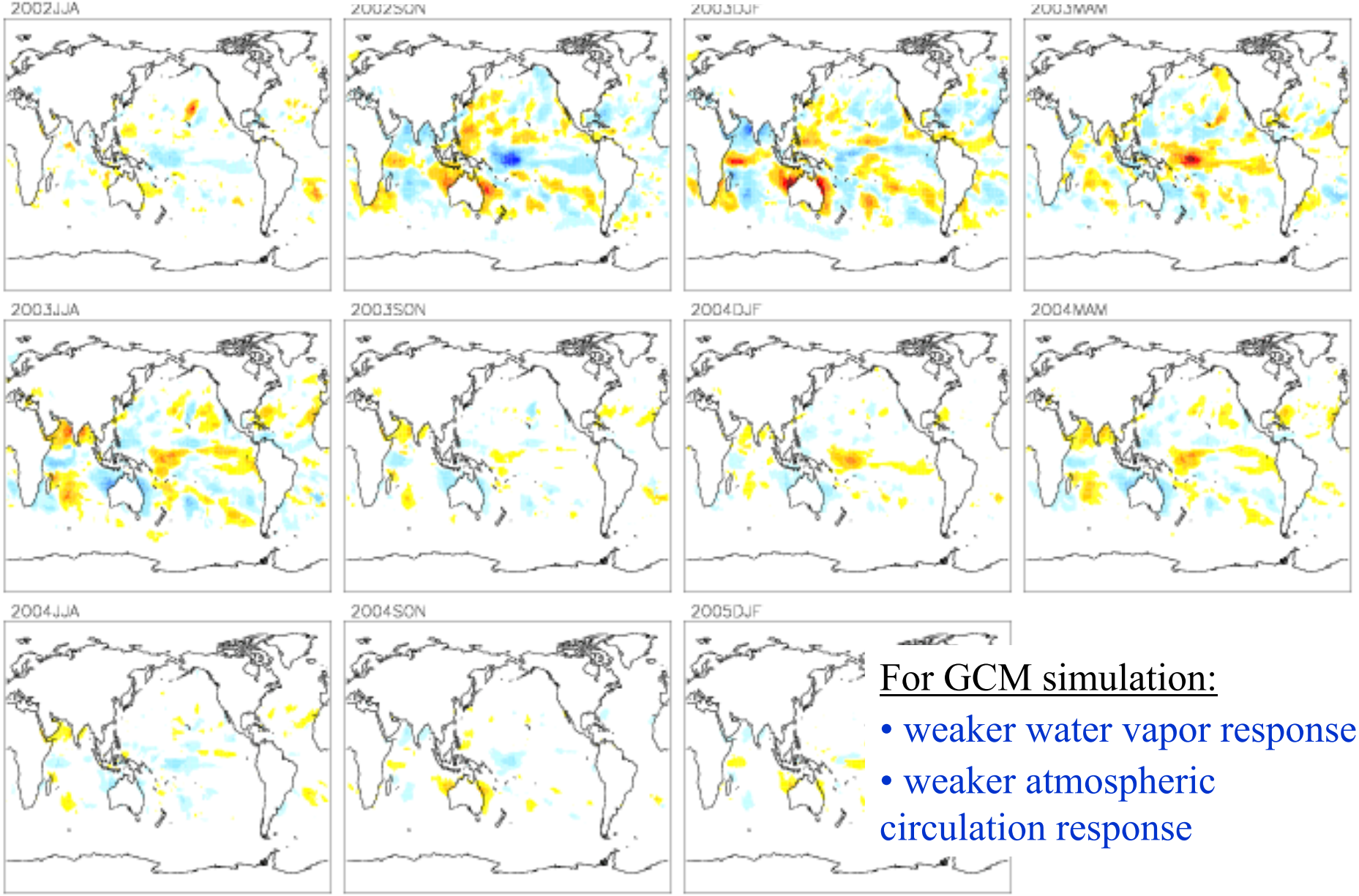
2002-03 El Niño Anomaly : AMSR-E Column Water Vapor (CWV)



CWV anomaly patterns

- positive anomalies in central and eastern Pacific, and negative ones over western Pacific and subtropics, which indicates
  - the shift of Walker circulation
  - the strengthen of Hadley cell

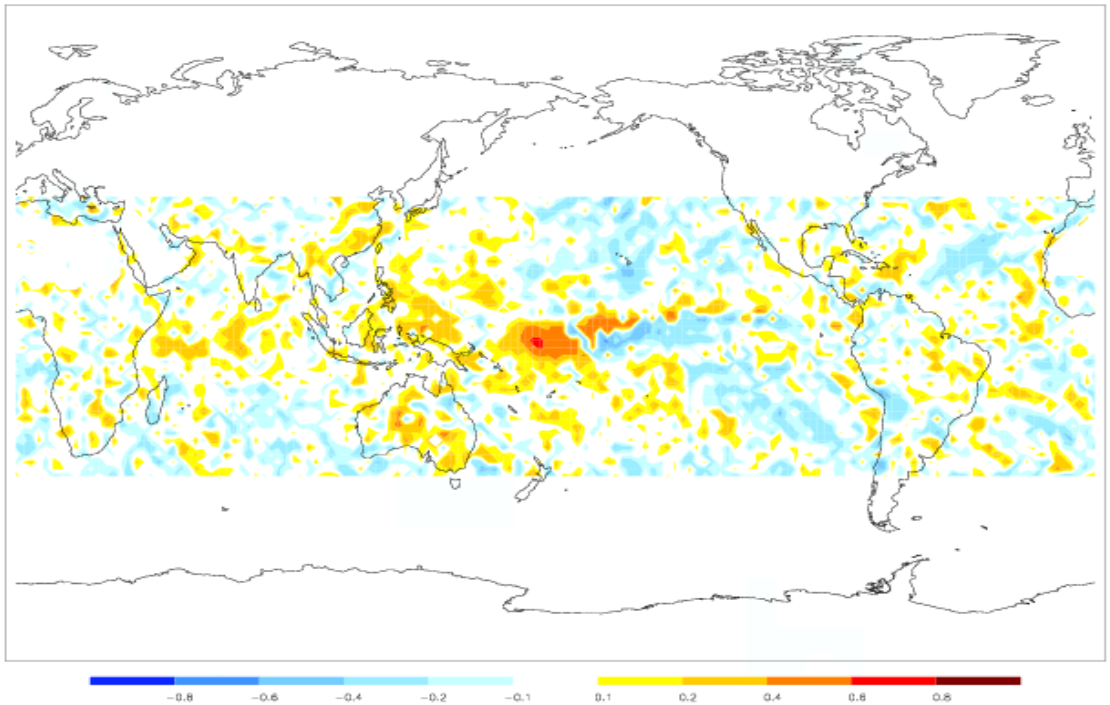
2002-03 El Niño Signal Difference GCM – AMSR-E CWV



For GCM simulation:

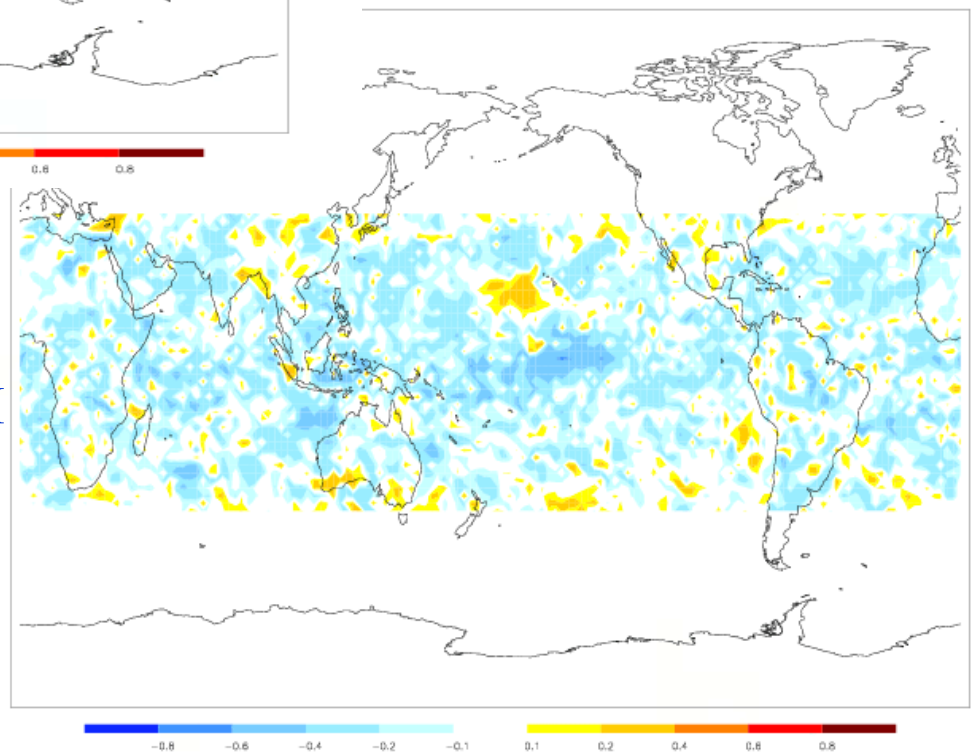
- weaker water vapor response
- weaker atmospheric circulation response

Correlation between Stratiform Rainfall Fraction (SFF) anomaly and PREC anomaly



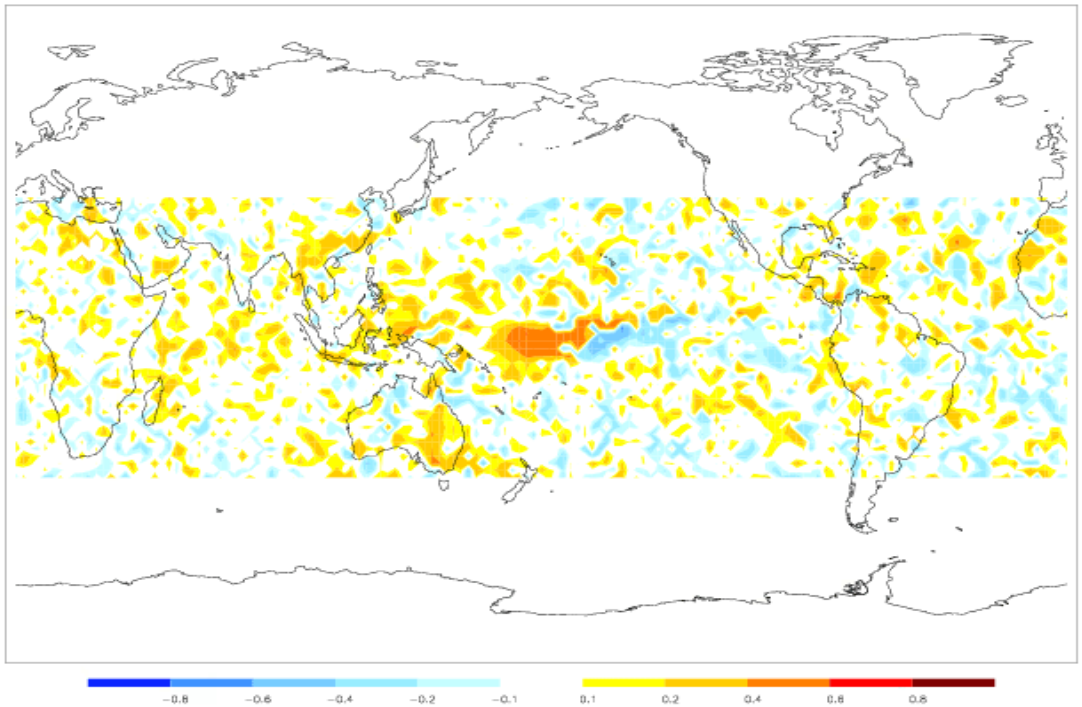
TRMM-3A12 (GPROF)

GCM



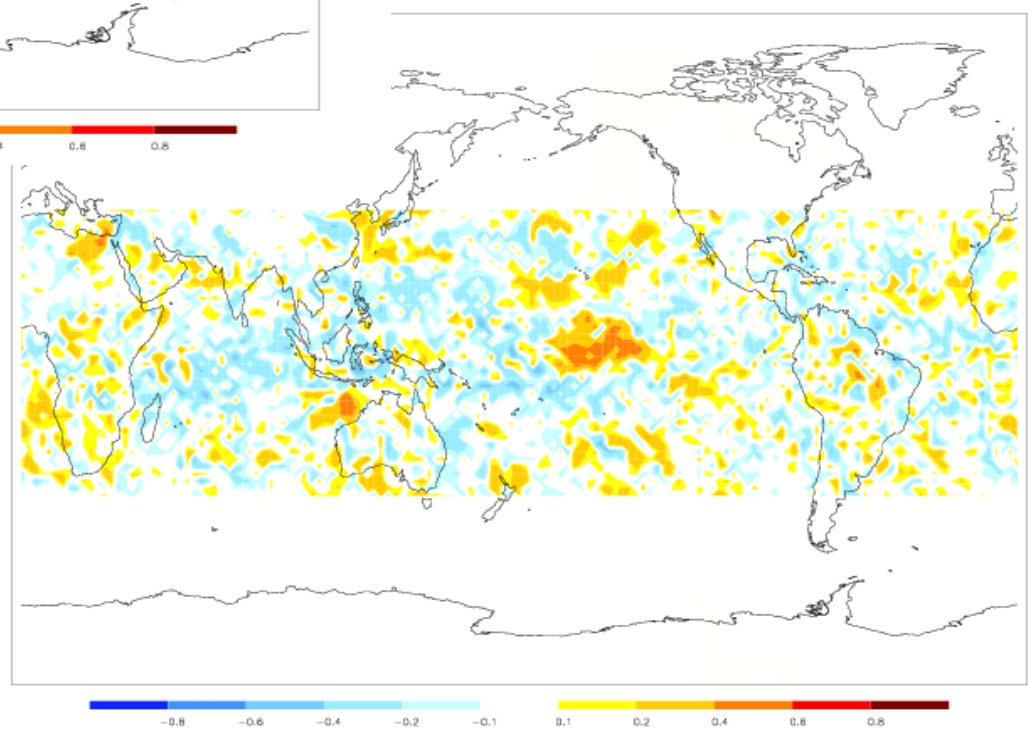
- **Anticorrelation dominates in GCM**
- **GCM produces higher convective rainfall fractions when producing more precipitation, but data show a more complicated pattern**

Correlation between Peak Latent Heating Altitude anomaly and PREC anomaly



TRMM-3A12 (GPROF)

GCM



- **More consistent pattern in TRMM than that in GCM**

Summary

- AMSR-E fields capture 2002-03 ENSO cycle
- GCM has not only a weaker El Niño precipitation response, but a weaker water vapor response, which indicates a weaker Hadley cell in response to SST anomaly.
- GCM produces higher convective rainfall fractions when producing more precipitation especially in El Niño regions, but data show a more complicated pattern, and correspondingly the latent heating profiles in GCM might be in a wrong shape

Comparison of GISS GCM and AMSR-E

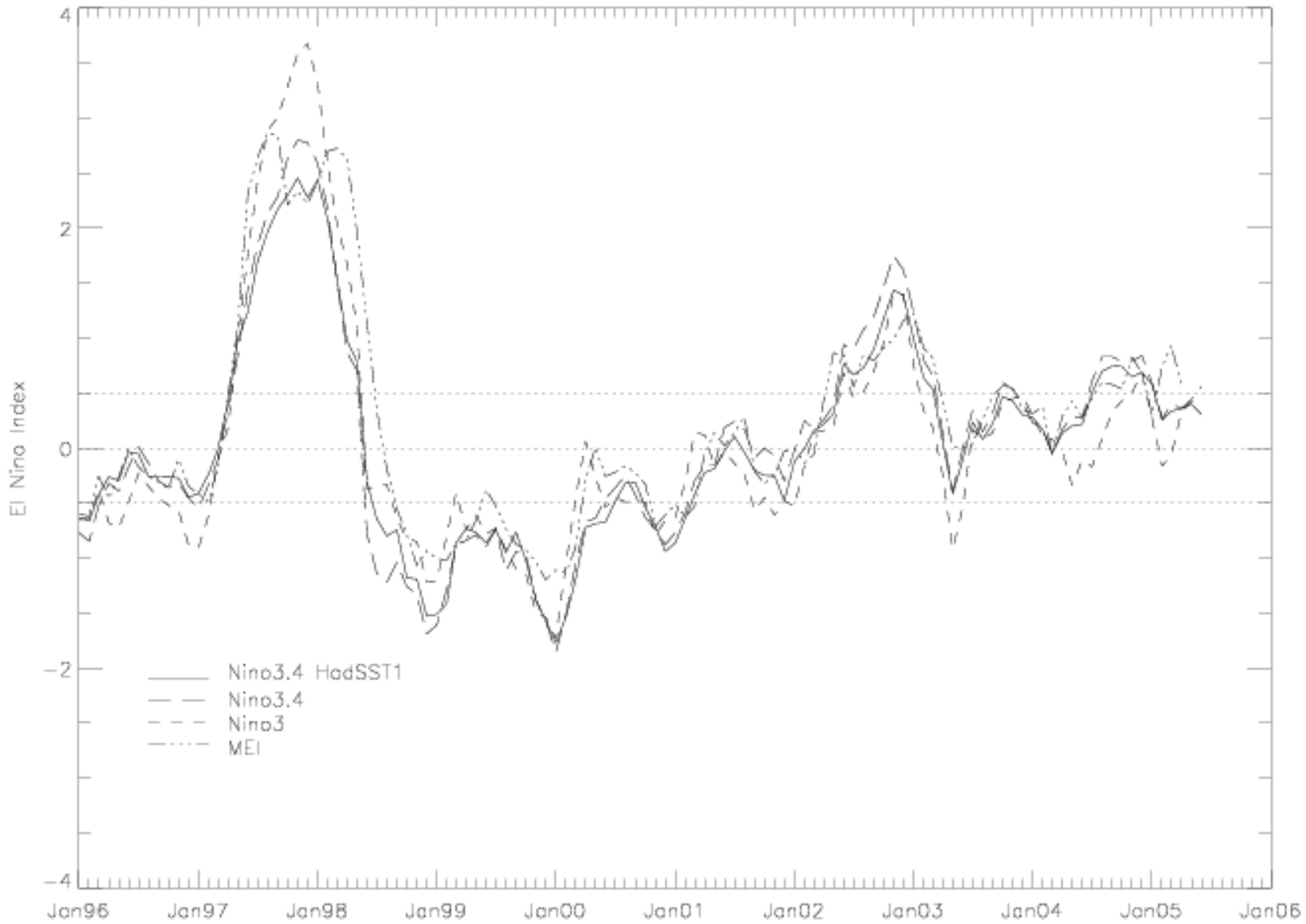
The End

Thanks for your attention

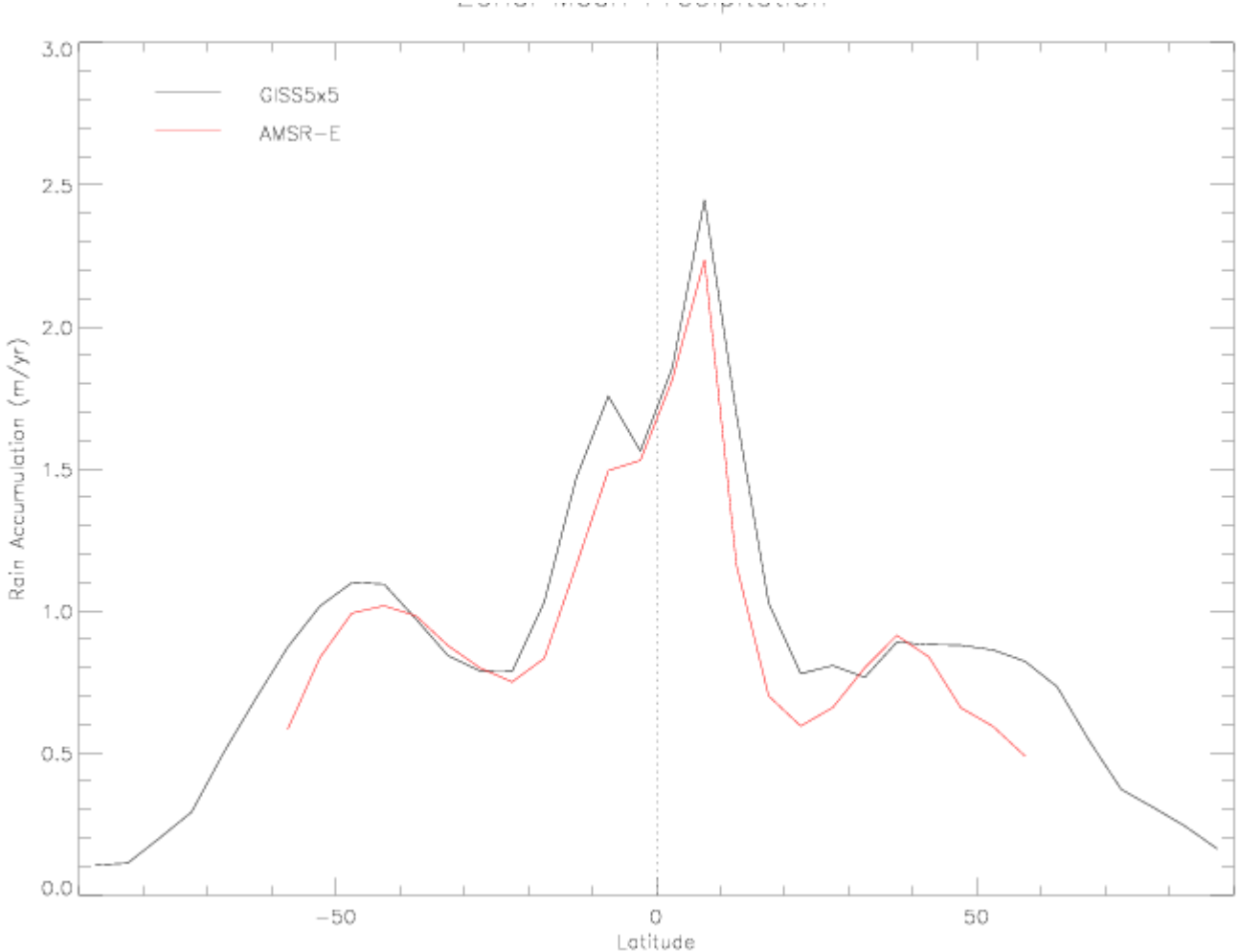
Possible sources of GCM errors (From last AMSR-E meeting)

- Precipitation anomalies (AMSR-E, TRMM)
- Latent heating profile anomalies (AMSR-E, TRMM)
- Radiative heating profile anomalies (TRMM, MODIS)
- Clear-sky water vapor problems (AMSR-E, AIRS)
- Marine stratocumulus anomalies (AMSR-E, MODIS)
- Circulation response to heating (ERA-40)

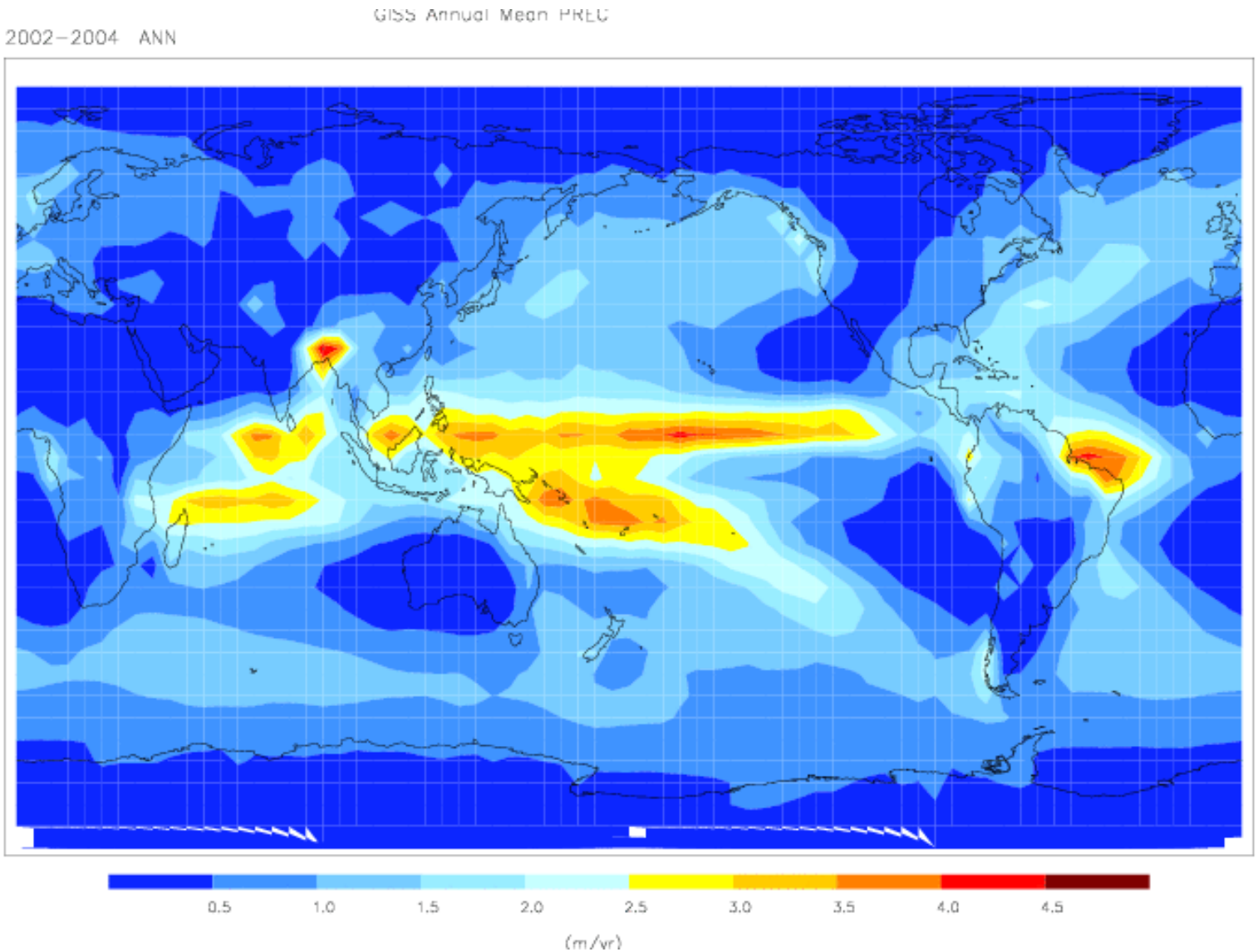
NINO3.4 Index



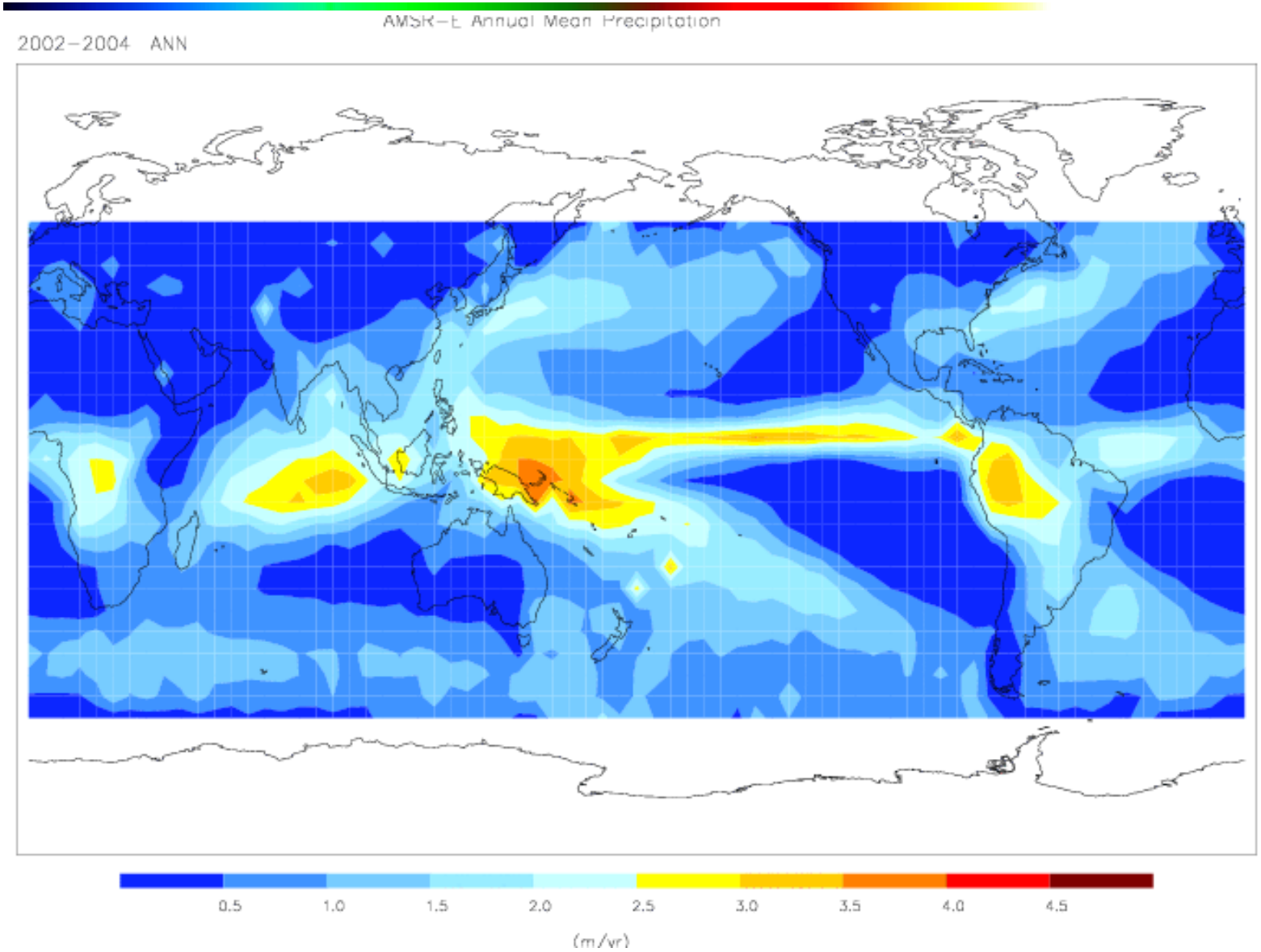
Model vs. AMSR-E Zonal Mean Precipitation



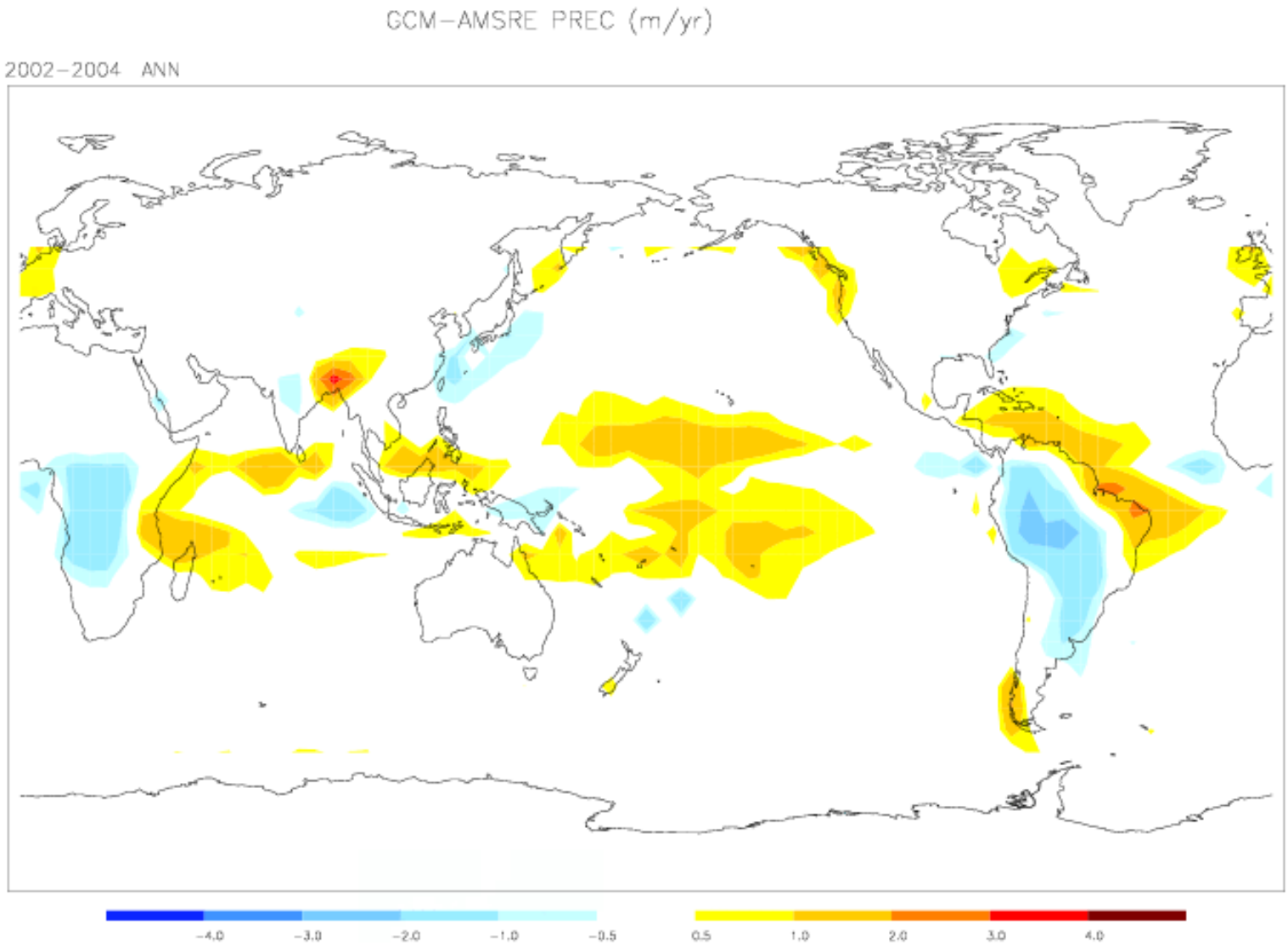
Model Annual Mean Precipitation



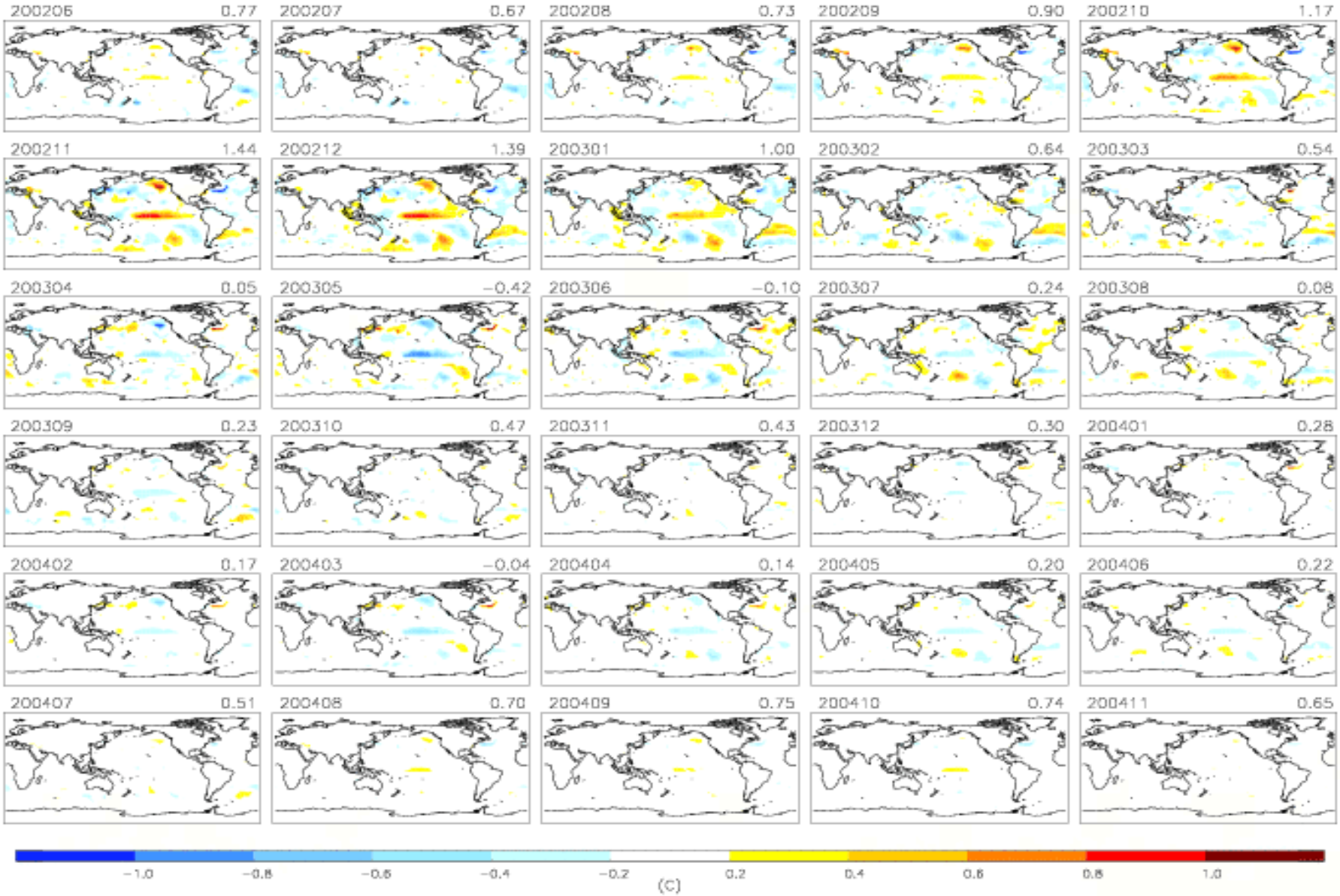
AMSR-E Annual Mean Precipitation



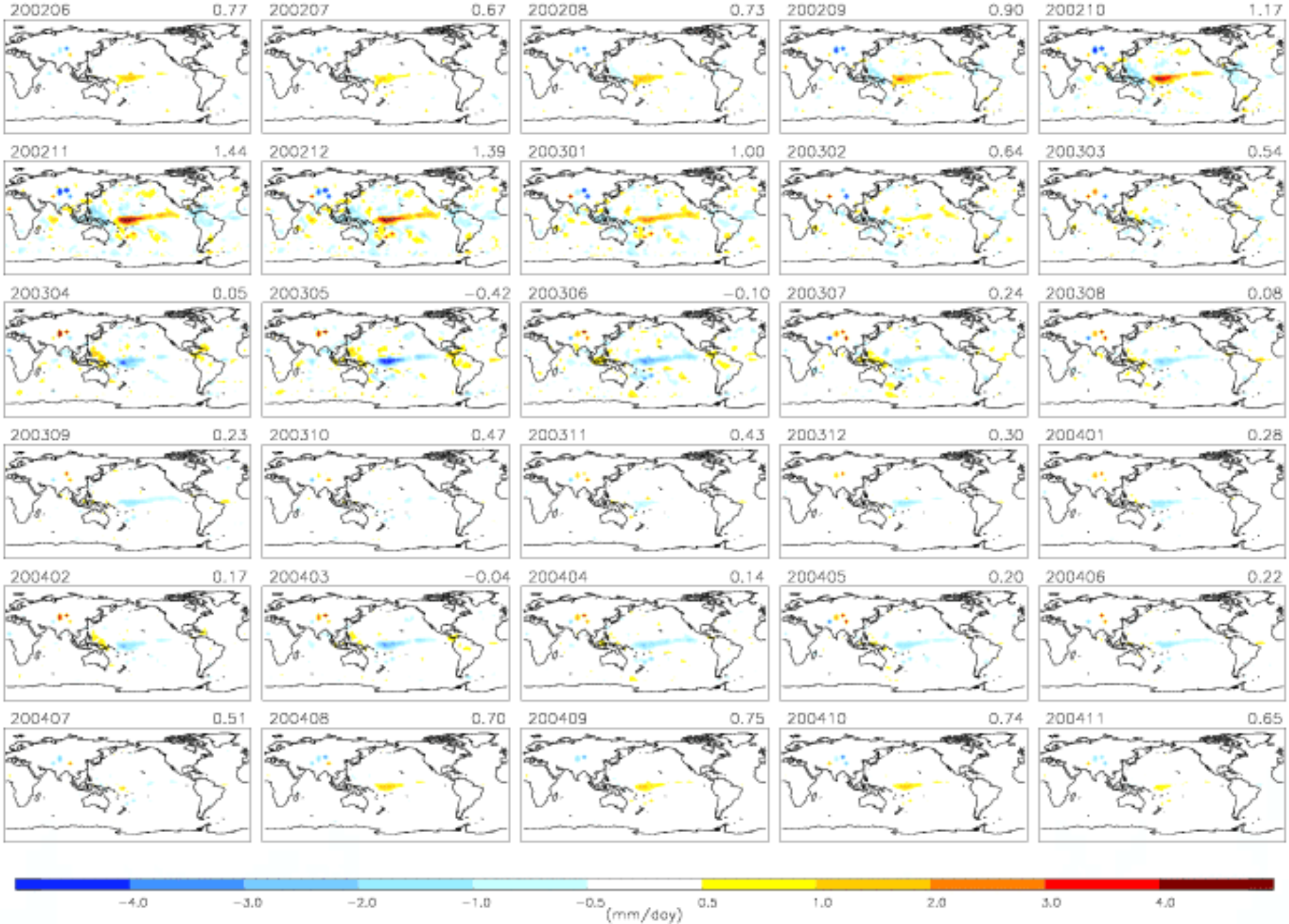
GCM – AMSR-E Annual Precipitation



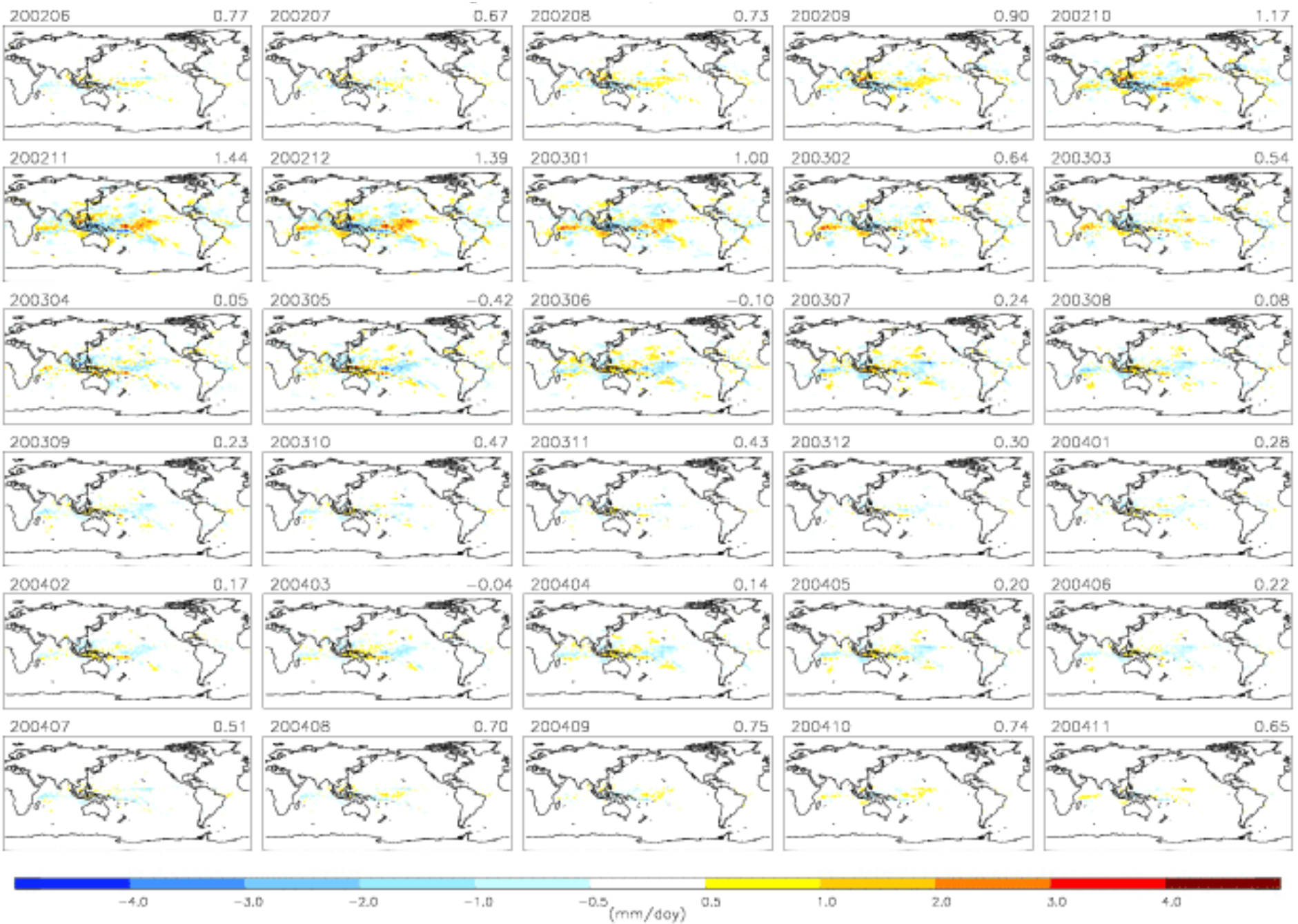
2002-03 El Nino Evolution in AMSR-E SST field



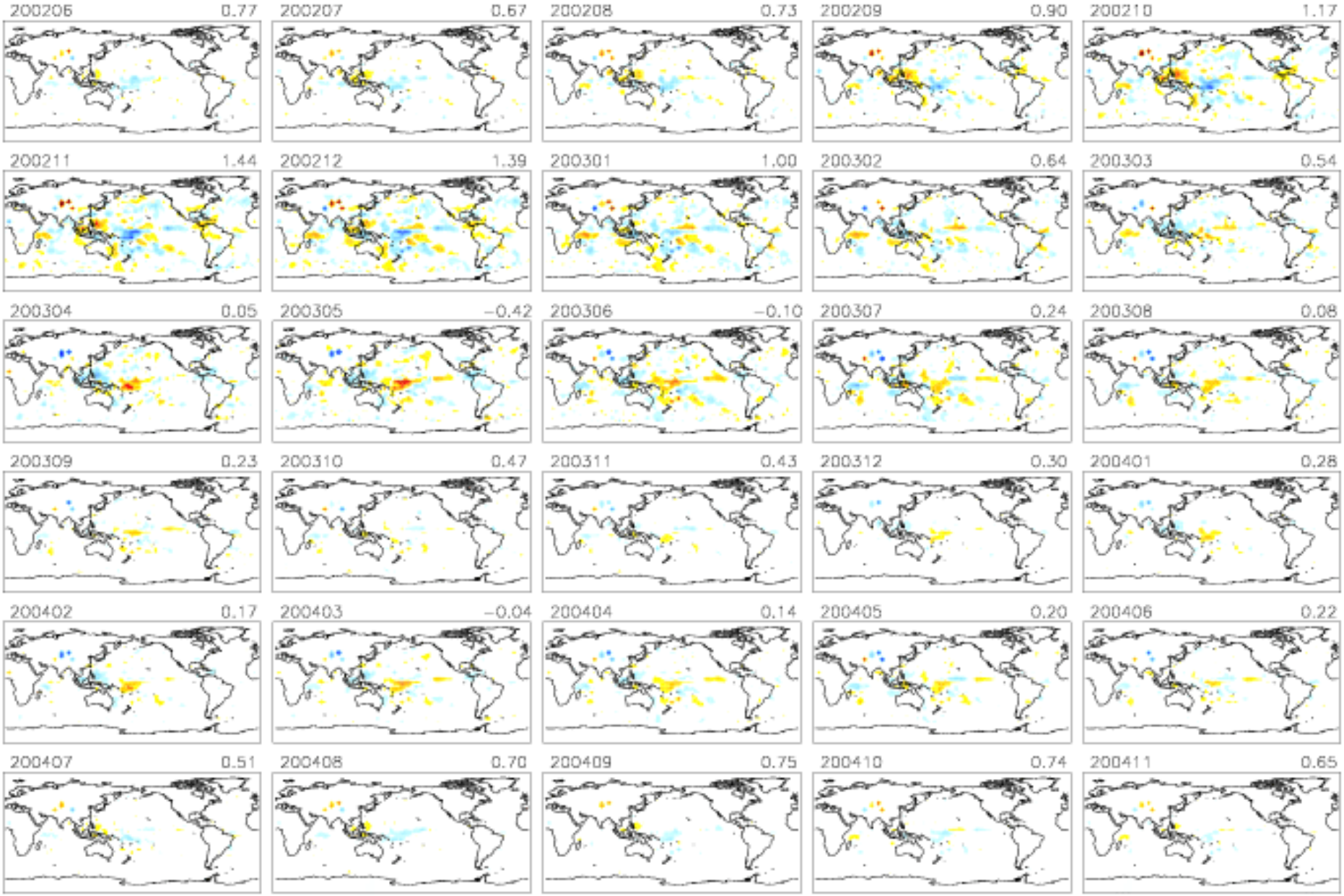
2002-03 El Nino Evolution in AMSR-E Precipitation



2002-03 El Nino Evolution in GISS GCM Precipitation field

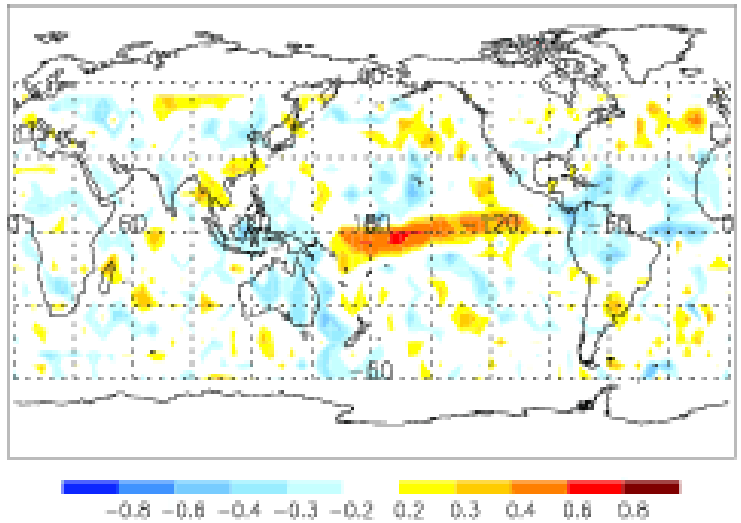


2002-03 ENSO Precipitation Signal Difference: GCM – AMSR-E

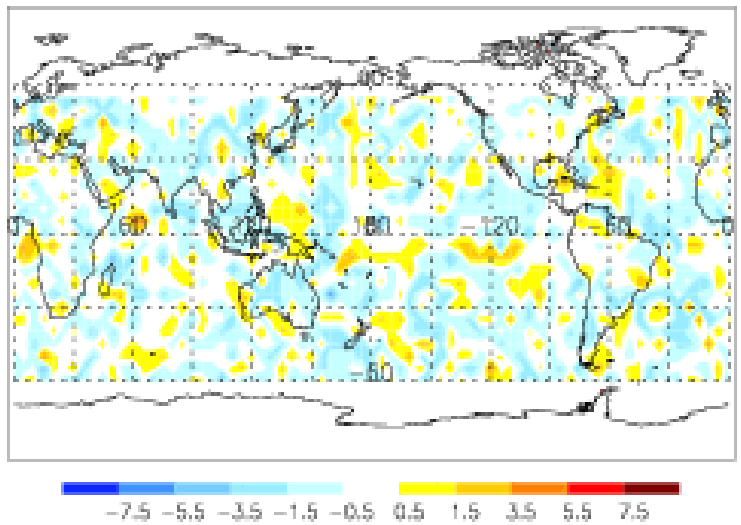


Correlation and Lag in AMSR-E Precipitation fields

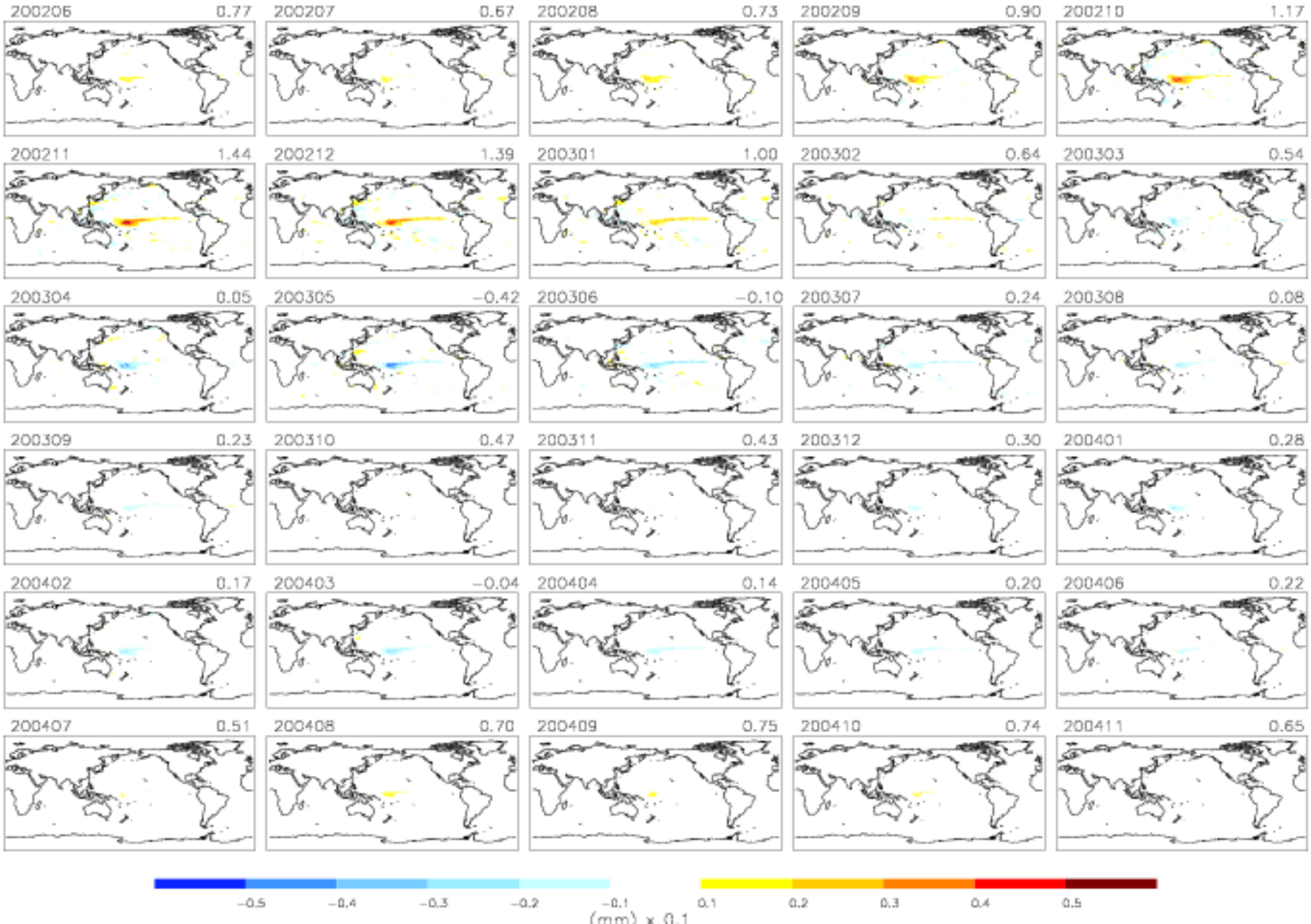
Extreme Correlation at Least Lag

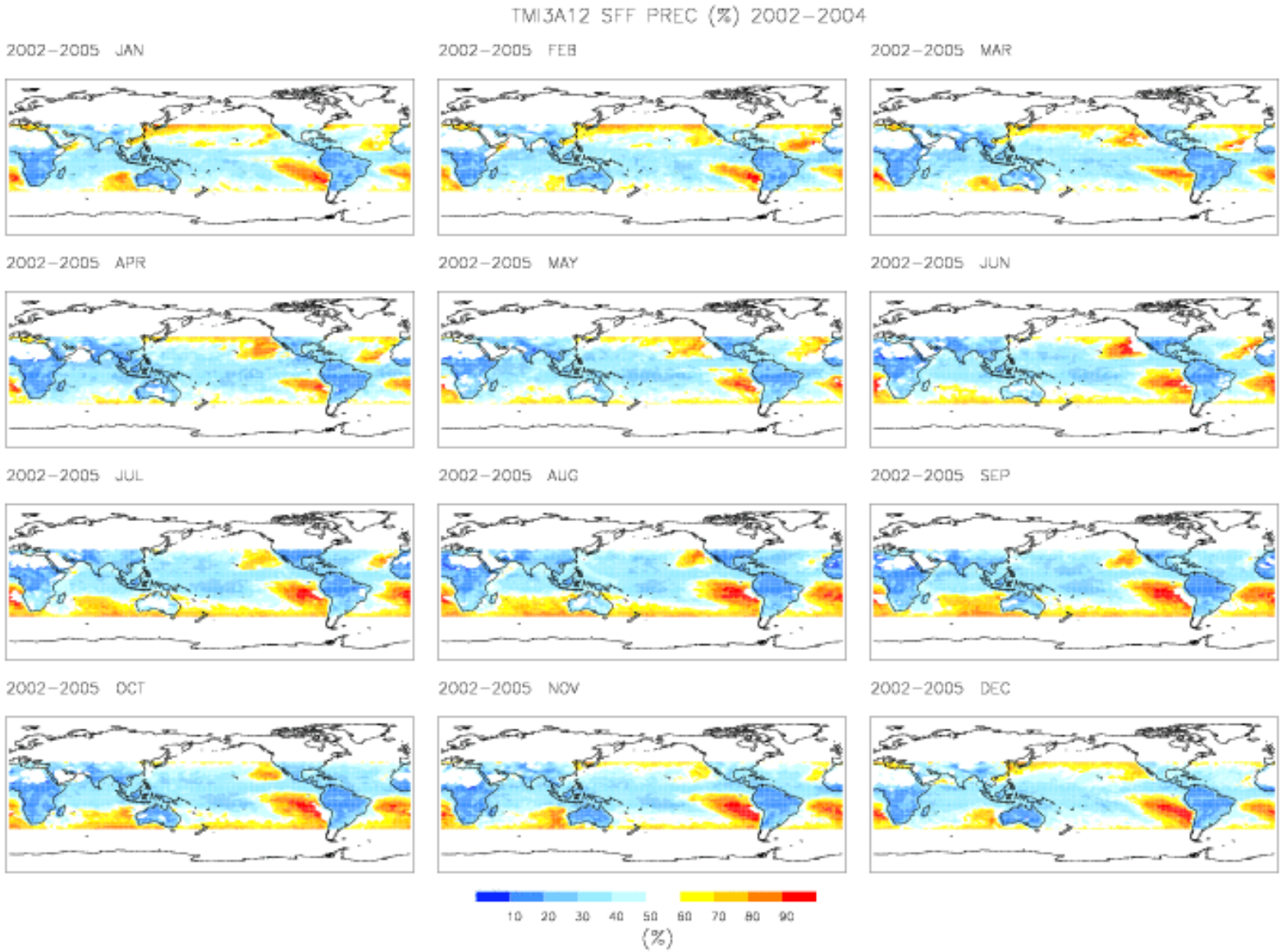


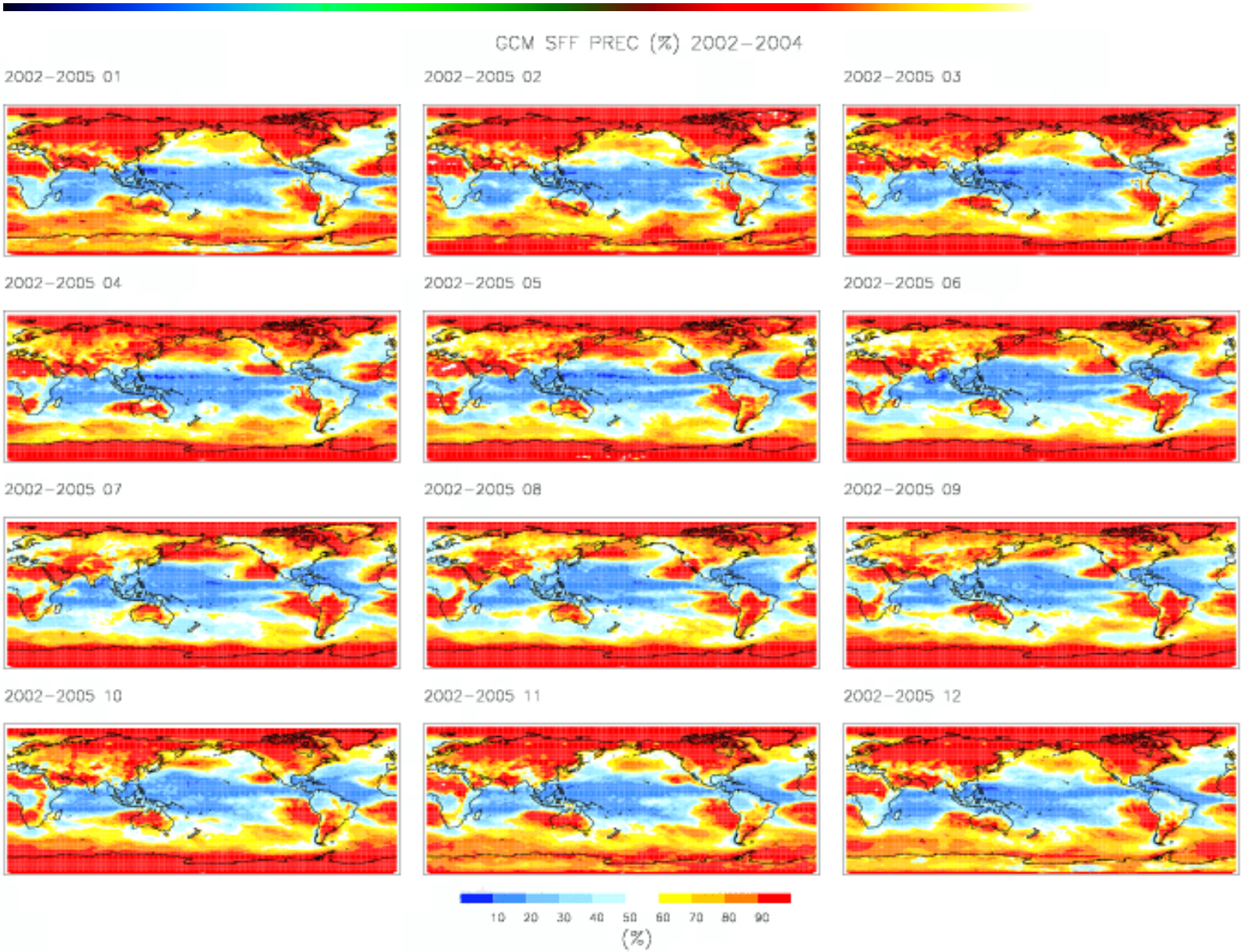
Lag (month)

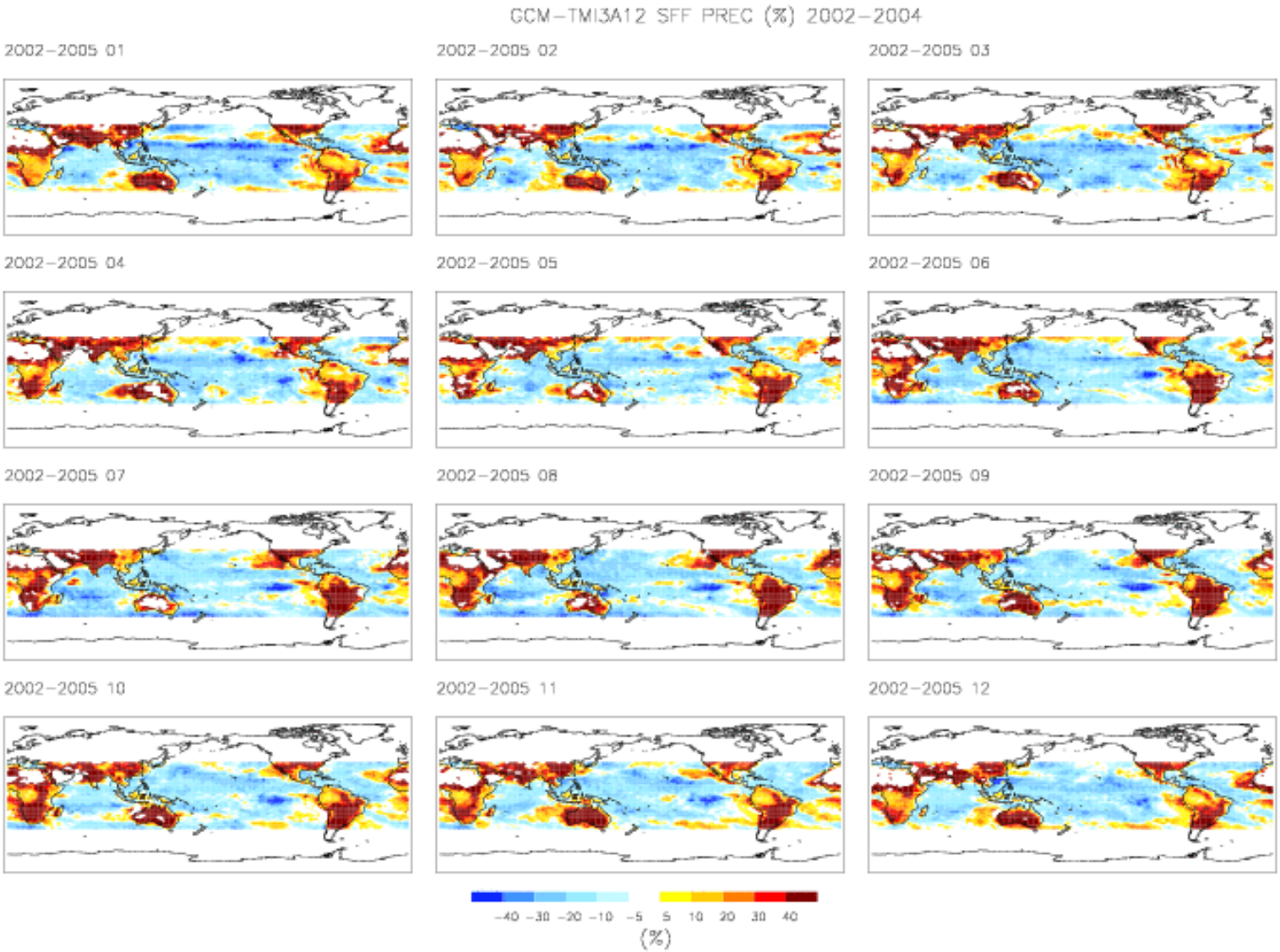


2002-03 El Nino Evolution in AMSR-E Cloud Liquid Water

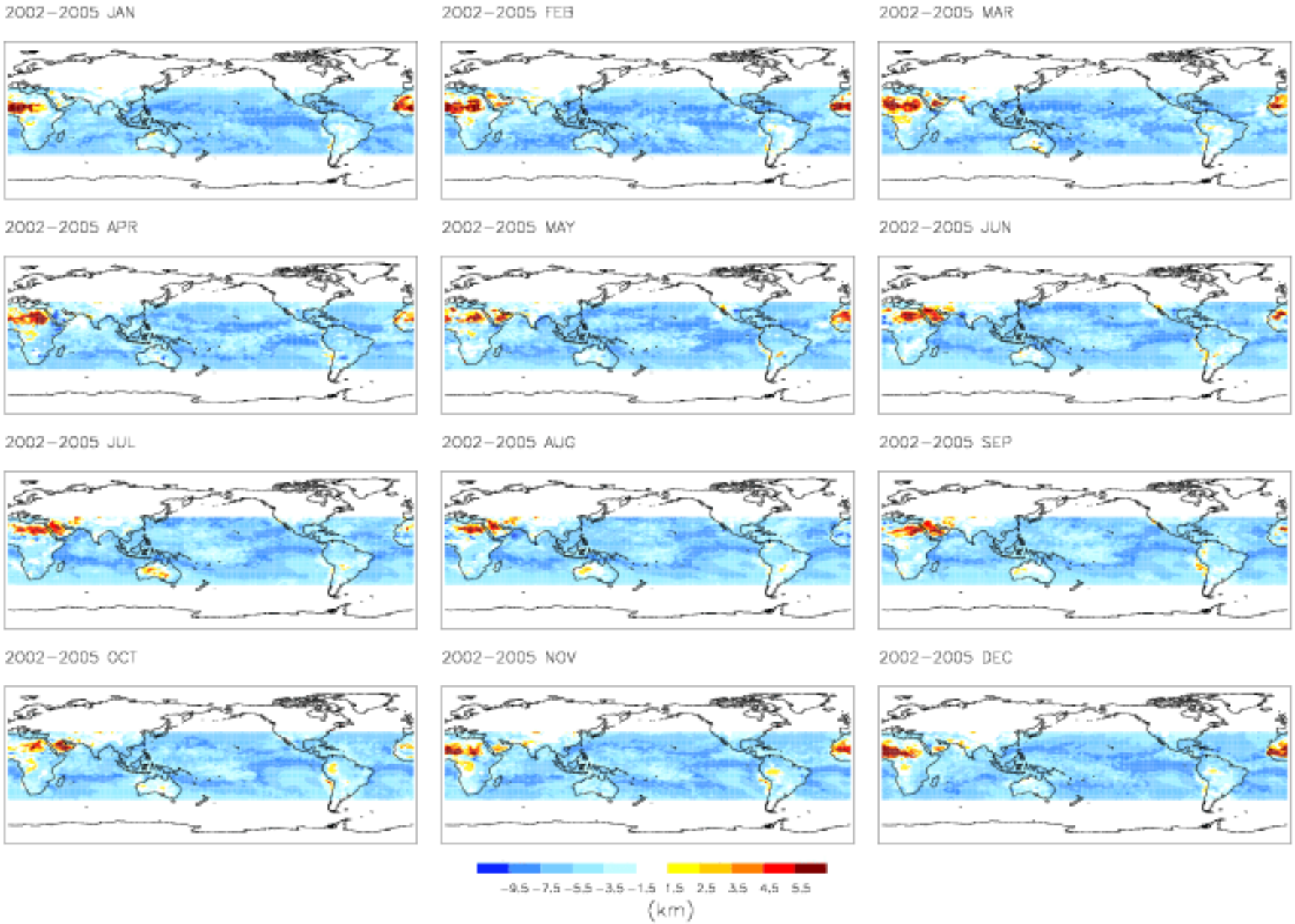



TMI3A12 SFF PREC (%) 2002-2004
2002-2005 JAN
2002-2005 FEB
2002-2005 MAR
2002-2005 APR
2002-2005 MAY
2002-2005 JUN
2002-2005 JUL
2002-2005 AUG
2002-2005 SEP
2002-2005 OCT
2002-2005 NOV
2002-2005 DEC
10 20 30 40 50 60 70 80 90
(%)

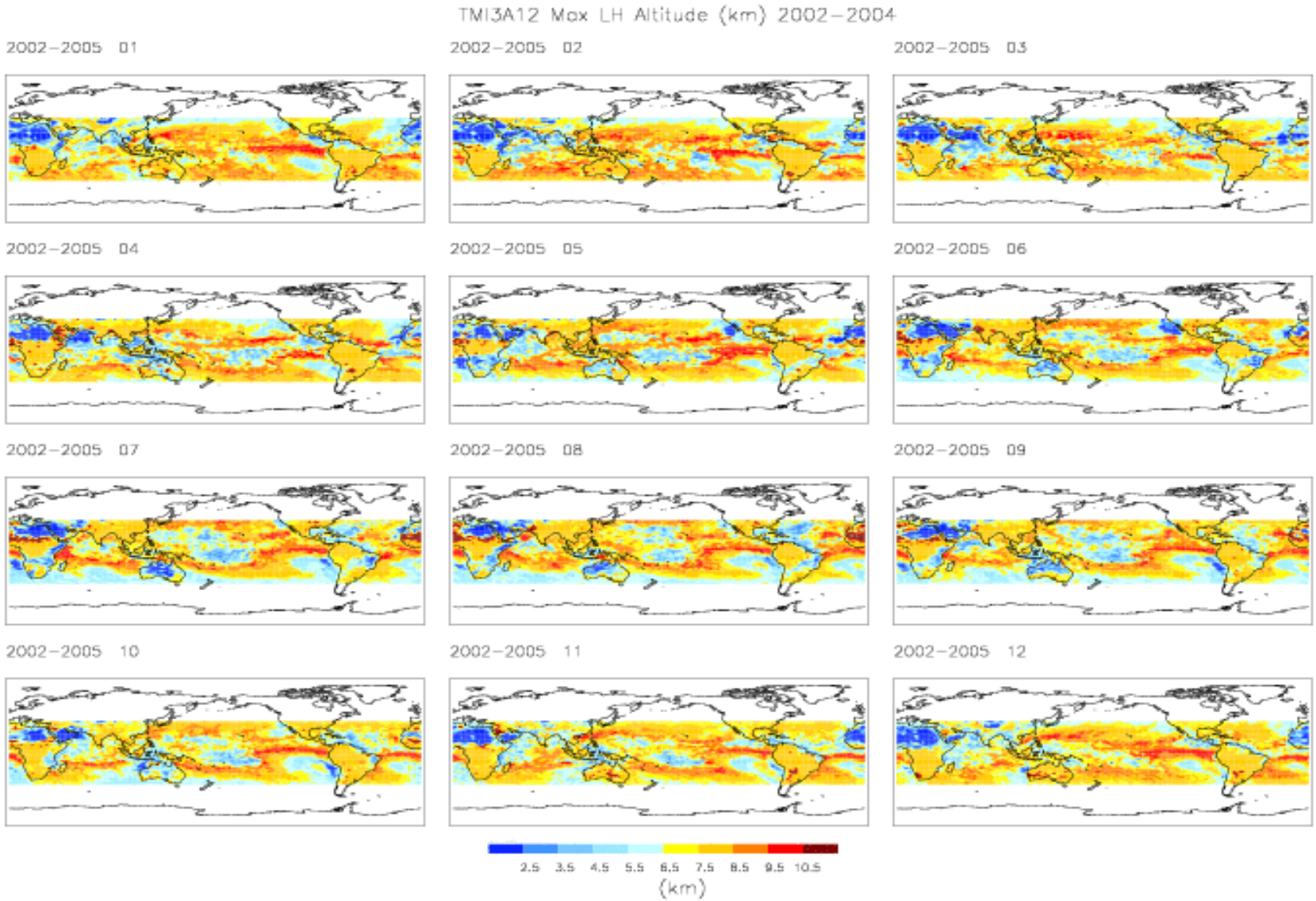

GCM SFF PREC (%) 2002-2004
2002-2005 01
2002-2005 02
2002-2005 03
2002-2005 04
2002-2005 05
2002-2005 06
2002-2005 07
2002-2005 08
2002-2005 09
2002-2005 10
2002-2005 11
2002-2005 12
10 20 30 40 50 60 70 80 90
(%)

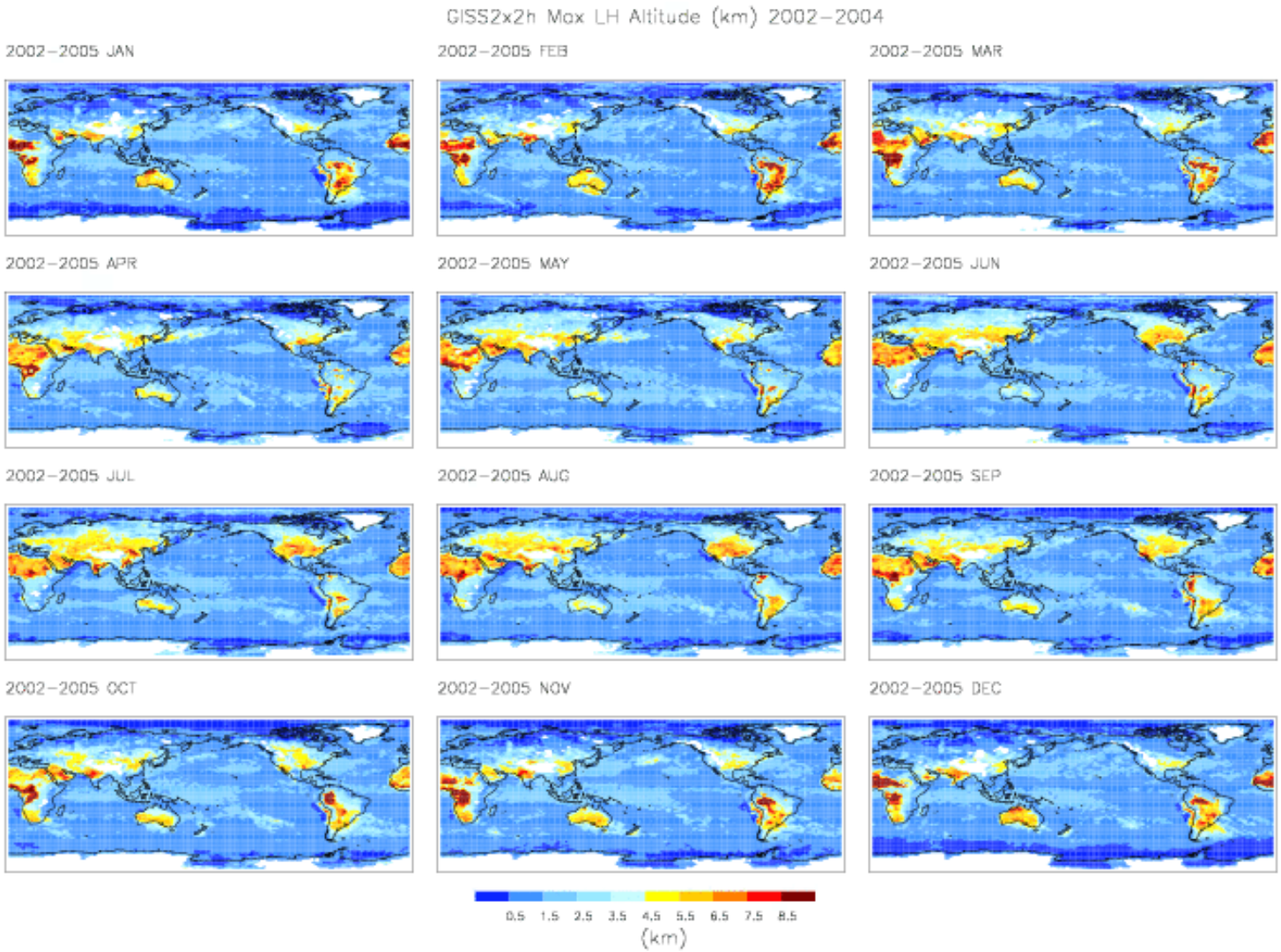

GCM-TMI3A12 SFF PREC (%) 2002-2004
2002-2005 01
2002-2005 02
2002-2005 03
2002-2005 04
2002-2005 05
2002-2005 06
2002-2005 07
2002-2005 08
2002-2005 09
2002-2005 10
2002-2005 11
2002-2005 12
-40 -30 -20 -10 -5 5 10 20 30 40
(%)

2002-03 Monthly Peak Latent Heating Altitude: GCM – TRMM

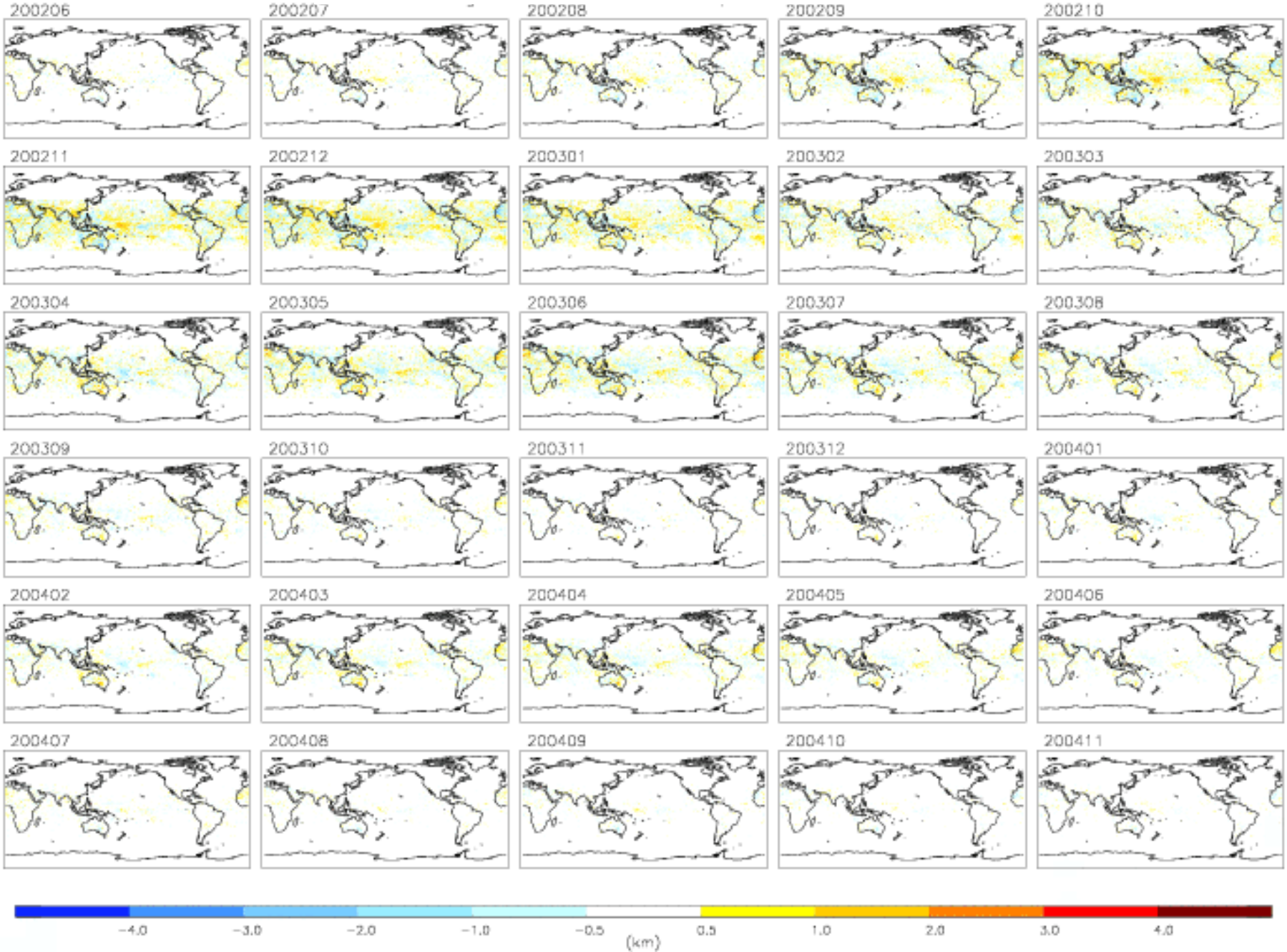


2002-03 Monthly mean Max Latent Heating Altitude: TRMM

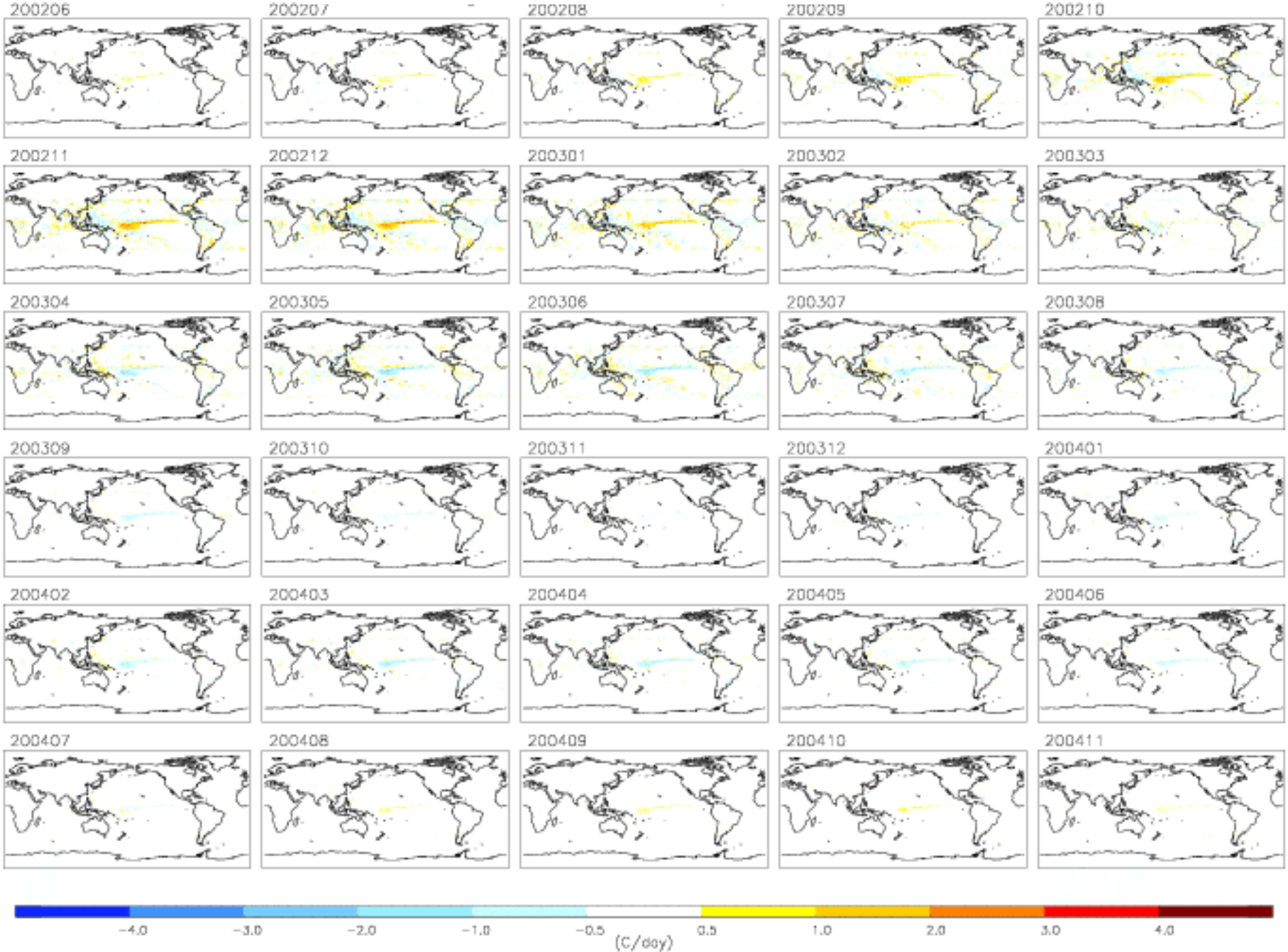



GISS2x2h Max LH Altitude (km) 2002–2004
2002–2005 JAN
2002–2005 FEB
2002–2005 MAR
2002–2005 APR
2002–2005 MAY
2002–2005 JUN
2002–2005 JUL
2002–2005 AUG
2002–2005 SEP
2002–2005 OCT
2002–2005 NOV
2002–2005 DEC
0.5 1.5 2.5 3.5 4.5 5.5 6.5 7.5 8.5
(km)

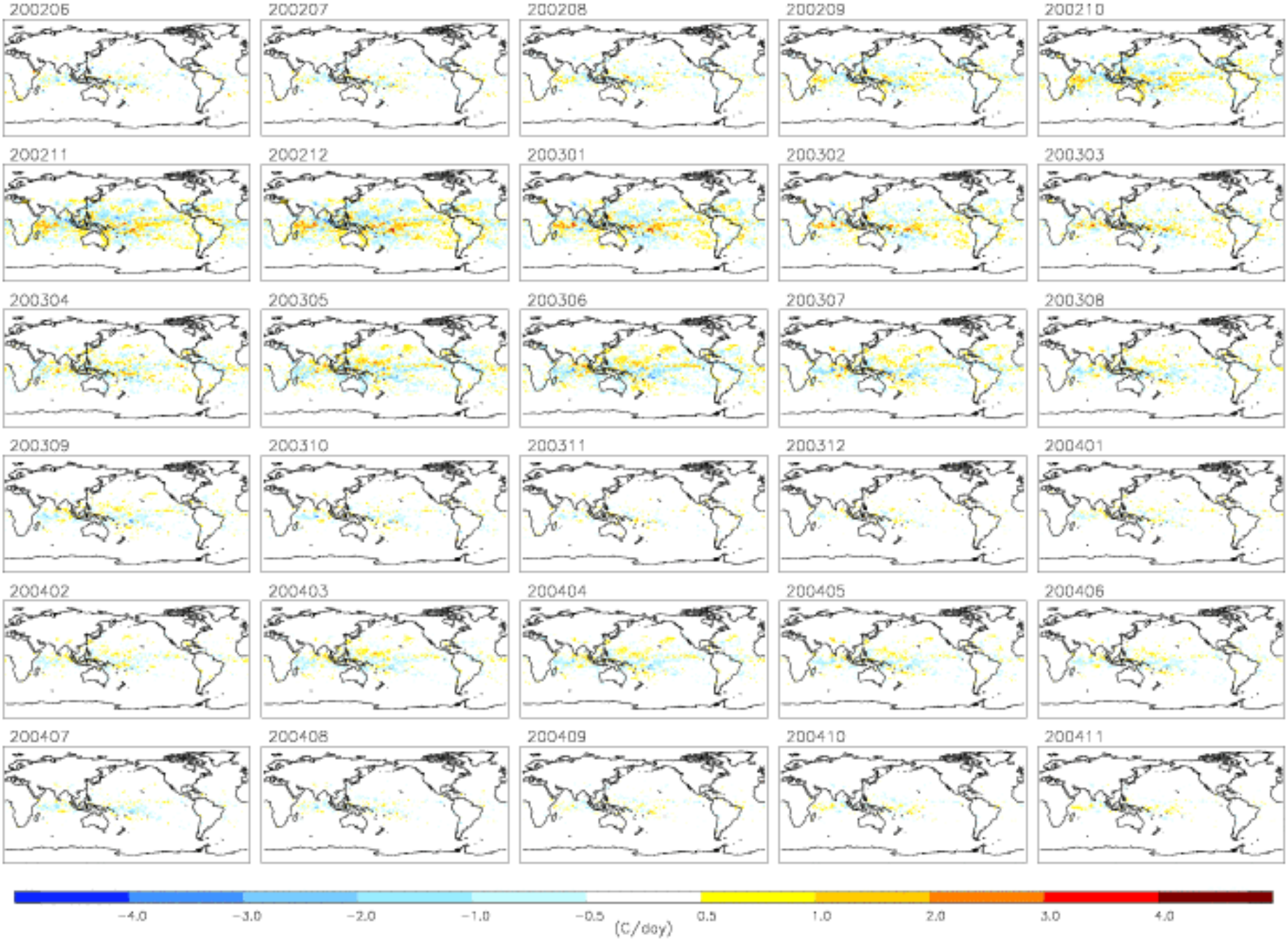
Maximum Latent Heating Altitude



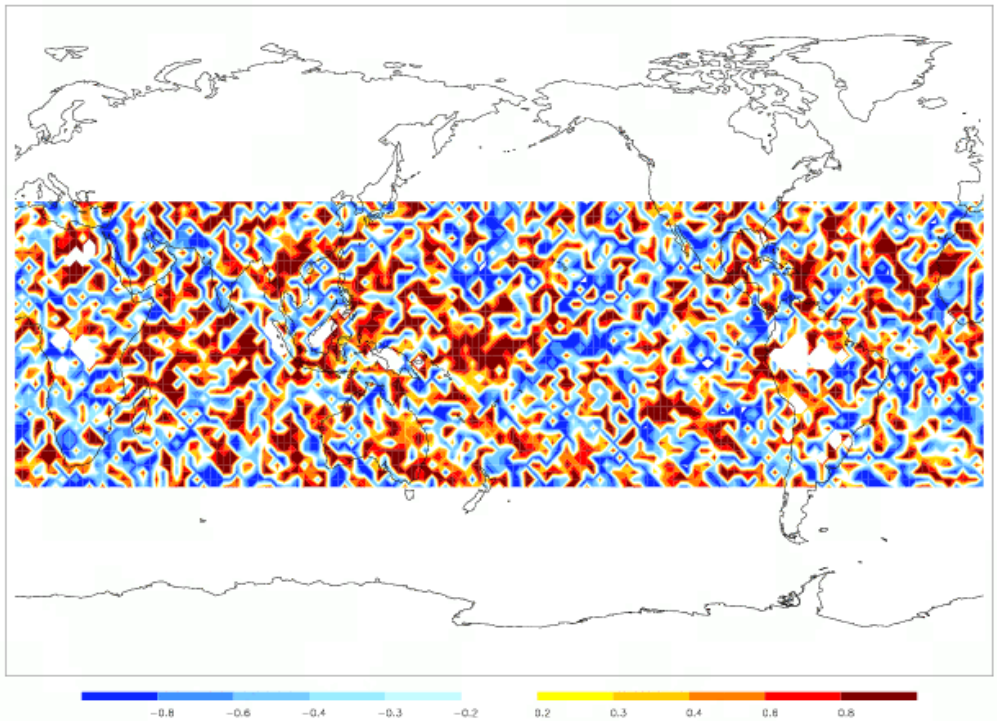
Maximum Latent Heating Magnitude



2002-03 El Nino Signal in Max Latent Heating: GCM – TRMM

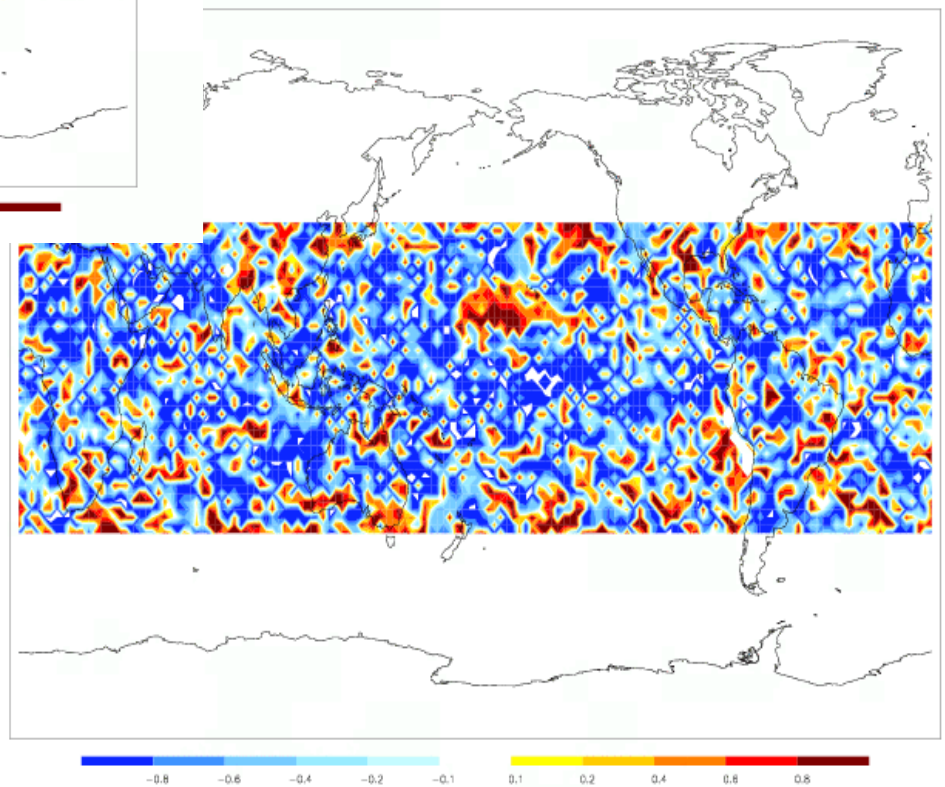


Correlation between Stratiform Rainfall Fraction (SFF) anomaly and PREC anomaly



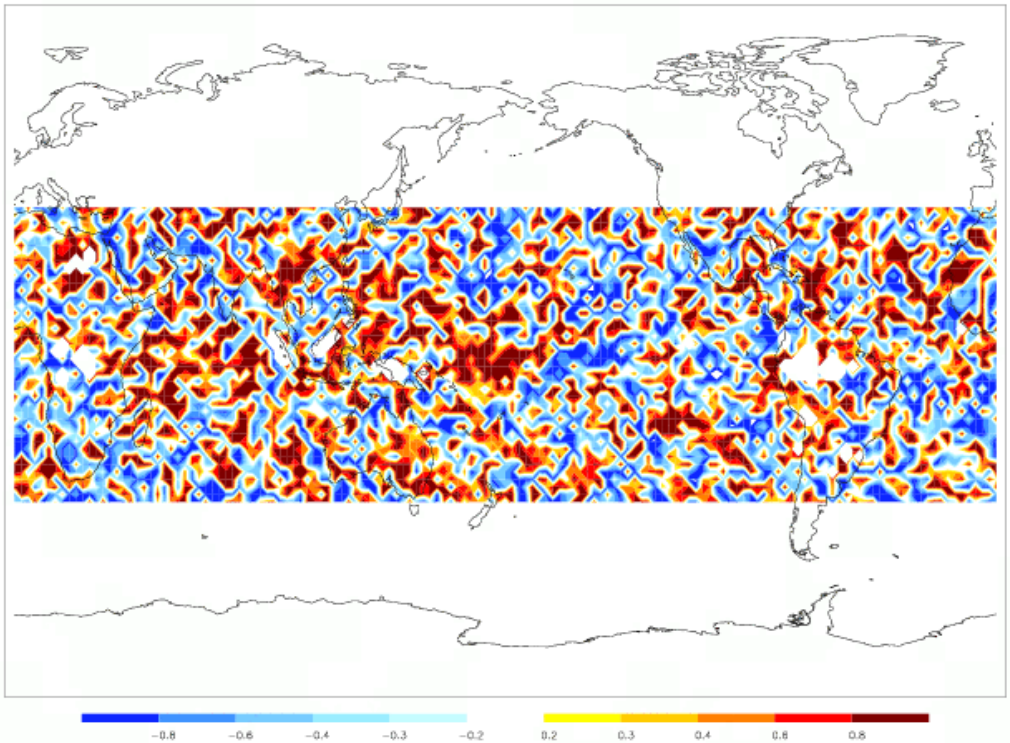
TRMM-3A12 (GPROF)

GCM



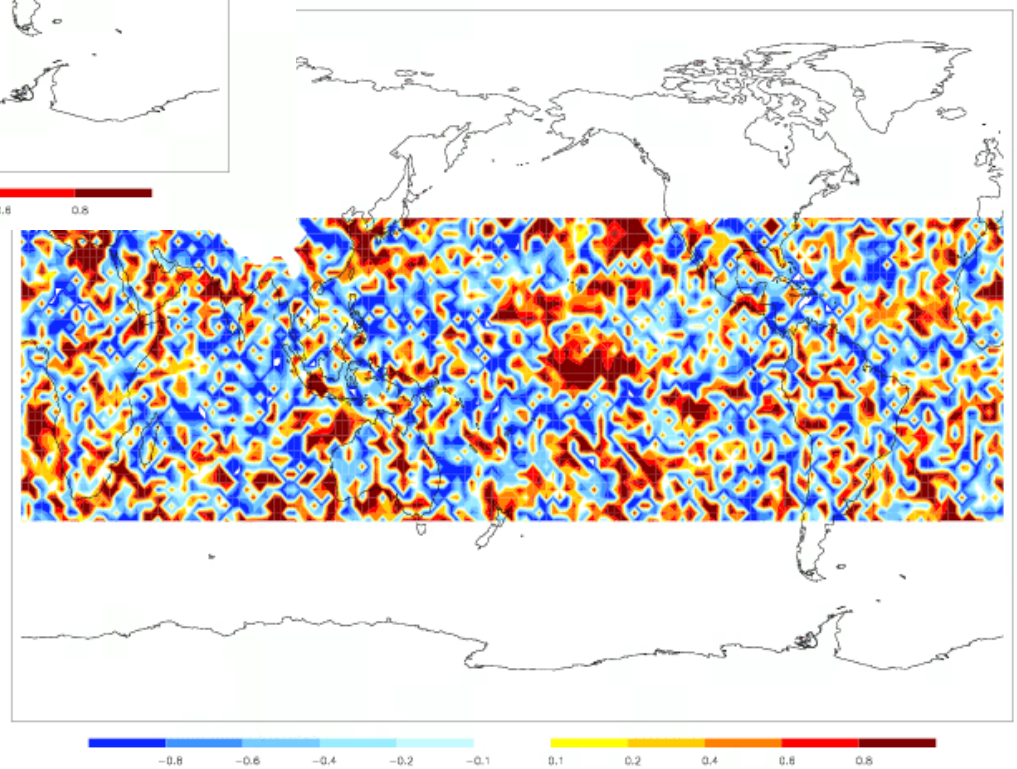
- **Anticorrelated dominates in GCM**
- **When getting more rainfall in GCM, a large fraction is in the convective form.**

Correlation between Peak Latent Heating Altitude anomaly and PREC anomaly



TRMM-3A12 (GPROF)

GCM



- **More consistent pattern in TRMM than that in GCM**